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# BOTANICAL GAZETTE

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## NEW OR LITTLE KNOWN NORTH AMERICAN TREES. III.

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**Crataegus acutifolia,** n. sp.—Glabrous. Leaves oval to oblong-obovate, acute or acuminate, or rarely rounded at the apex, cuneate at the base, finely crenulate-serrate with gland-tipped teeth except toward the base, or occasionally only above the middle, on vigorous leading shoots sometimes irregularly divided toward the apex into two or three pairs of short acute lobes; nearly fully grown when the flowers open and then thin and lustrous above and at maturity thin but firm in texture, dark green and very lustrous on the upper surface, pale yellow-green on the lower surface, about 1½ in. long and 1 in. wide, and on leading shoots sometimes 2½ to 3 inches long and nearly 2 in. wide, with slender light yellow midribs comparatively deeply impressed above, and four or five pairs of thin primary veins without the parenchyma; petioles slender, winged above by the decurrent bases of the leaf-blades, deeply grooved, glandular with minute dark caducous glands, from ¼ to ⅓ in. in length; stipules linear, elongated, dark red, caducous. Flowers ½ in. in diameter on slender pedicels, in compound many-flowered compact corymbs; bracts and bractlets linear, glandular-serrate, caducous; calyx-tube narrowly obconic, the lobes lanceolate, acuminate, entire or occasionally obscurely glandular-serrate; stamens 10; filaments slender, elongated; anthers small; styles

2 or 3. Fruit in drooping few-fruited clusters, oblong, full and rounded at the ends, bright scarlet, marked by few large dark lenticels, about ⅓ in. long; calyx-tube prominent with a broad deep cavity, the lobes closely appressed, often deciduous before the maturity of the fruit; flesh thin, yellow, dry and mealy; nutlets 2 or 3, broad, prominently ridged on the back with broad rounded ridges, about $\frac{3}{16}$ in. long.

A tree 25 to 30 ft. in height with a trunk 8 or 10 in. in diameter, and wide-spreading branches forming a broad symmetrical rather flat-topped head and slender nearly straight branchlets marked by oblong pale lenticels, dark chestnut-brown or orange-brown and lustrous during their first year, becoming dull gray-brown during their second season, and slightly armed with few slender straight chestnut-brown spines from 1 to nearly 2 in. in length.

Flowers early in May. Fruit ripens toward the end of September.

Open oak woods near the bank of the Mississippi river at Carondelet in South St. Louis, Missouri. First collected in May 1887 by *H. Eggert*, and in September 1900 by *Eggert*, *Norton*, and *Sargent*.

This is one of several forms which have been usually confounded with *Crataegus Crus-galli* of Linnaeus, but which can probably best be separated from that species. From *Crataegus Crus-galli* as limited by Linnaeus and Aiton, and now universally recognized, it differs in its thin usually acute or acuminate leaves with comparatively prominent veins, in its smaller flowers, much smaller early-ripening scarlet fruit, and in its more slender branchlets only sparingly armed with much more slender spines.

**Crataegus erecta,** n. sp.—Glabrous. Leaves broadly oval to obovate, or on leading shoots nearly orbicular, acute and short-pointed at the apex, cuneate and entire at the base, finely crenulate-serrate above, or on vigorous shoots coarsely dentate with broad nearly straight gland-tipped teeth, thin, dull green and nearly fully grown when the flowers open, and at maturity thin but firm in texture, dark dull green on the upper surface, pale on the lower surface, 1½ to 2 in. long, 1 to 1¼ in. wide, and on leading shoots sometimes 3 in. long and 2½ in. wide, with

slender midribs and thin prominent primary veins; petioles slender, deeply grooved, wing-margined above particularly on vigorous shoots, glandular with minute dark glands, often dark red after midsummer, from ¼ to ½ in. long; stipules linear, glandular-serrate, fading red, ½ in. long, caducous. Flowers ½ to ⅝ in. in diameter, on slender elongated pedicels, in broad loose many-flowered very thin-branched compound corymbs; bracts and bractlets linear, glandular-serrate, caducous; calyx-tube narrowly obconic, the lobes narrow, acuminate, elongated, entire or occasionally obscurely dentate; stamens usually 10, occasionally 11 to 13; filaments slender; anthers small, pale yellow; styles 3 or 4, surrounded at the base by a narrow ring of short pale hairs. Fruit in few-fruited drooping clusters, subglobose, usually a little longer than broad, full but flattened at the ends, dark dull crimson, marked by occasional large dark lenticels, from ¼ to ⅓ in. in length; calyx-tube very short with a broad shallow cavity, the lobes gradually narrowed from broad bases, closely appressed, usually persistent on the mature fruit; flesh thin, yellow, dry and mealy; nutlets 3 or 4, broad, prominently doubly ridged on the back, about $\frac{3}{16}$ in. long.

A tree usually 25 to 30 ft. in height with a trunk a foot in diameter covered with dark gray-brown or nearly black bark broken irregularly into thick plate-like scales, ascending branches forming a broad open erect head and slender slightly zigzag branchlets marked by numerous large oblong pale lenticels, green more or less tinged with red when they first appear, orange or reddish-brown during their first season and gray or gray-brown during their second year, and armed with numerous straight slender chestnut-brown spines from 1 to 2 in. in length.

Flowers about May 10. Fruit ripens toward the end of September. The leaves before falling turn dull orange-color.

Rich bottom-lands of the Mississippi river in Illinois opposite St. Louis. First noticed October 5, 1899, in a vacant lot in the city of East St. Louis by *Eggert*, *Norton*, and *Sargent*, and on May 12, 1900, collected in flower by *J. B. S. Norton*, and in October 1900 with ripe fruit by *Eggert*, *Norton*, and *Sargent*.

This is another of the *Crus-galli* group, differing from the species of Linnaeus by its thin pointed or suborbicular leaves with prominent veins, which even on vigorous shoots show no tendency to lobing, by its pale yellow not rose-colored anthers, small nearly globose bright scarlet fruit, by its ascending not wide-spreading branches, and by its less numerous spines standing out from all sides of the branchlets, as they do usually in Crataegus with the exception of *Crataegus Crus-galli*. This species in its typical form can always be recognized by the direction of the spines which point downward from the branch in two ranks.

Growing in a field in the Mississippi bottom near Fish lake in the village of Cahokia about four miles below East St. Louis there is a specimen of *Crataegus erecta* forty feet in height with a trunk three feet in diameter three feet above the surface of the ground and a broad head of numerous large upright branches.

**Crataegus Lettermani,** n. sp.—Leaves obovate to broadly oval on leading shoots, acute, acuminate or rounded and short-pointed at the apex, gradually narrowed from near the middle to the base and decurrent on the stout elongated glandular tomentose but ultimately nearly glabrous petioles, often slightly and irregularly divided above into three or four pairs of short acute lobes, coarsely doubly serrate, often nearly to the base, with glandular incurved or straight teeth; as they unfold strongly plicate, tomentose above and below like the young branchlets, with a thick coat of hoary tomentum, and when the flowers open covered on the upper surface with short soft hairs and villose on the lower surface, and at maturity thin but firm in texture, scabrate and dark green above, pale below, from 2 to 2½ in. long and from 1 to 1½ in. wide, with slender midribs and primary veins impressed on the upper surface and puberulous below, and conspicuous forked secondary veins and reticulate veinlets. Flowers about ¾ in. in diameter in compact many-flowered thick-branched tomentose cymes; bracts and bractlets linear, glandular-serrate, caducous; calyx-tube narrowly obconic, coated with thick hoary tomentum, the lobes narrow, acuminate, villose, finely glandular-serrate, reflexed after anthesis; stamens 10; filaments slender, elongated; anthers small; styles 5, surrounded at the base by a broad ring of white tomentum. Fruit nearly globose and somewhat flattened at the

ends, dark red, marked by a few large pale lenticels, 5/8 in. in diameter; calyx-cavity broad and shallow, the lobes serrate, villose, spreading and closely appressed; flesh thin and yellow; nutlets 5, thick, very prominently doubly ridged on the back, about 1/4 in. long.

A tree from 15 to 18 ft. in height, with a trunk 6 or 8 in. in diameter, and stout wide-spreading branches forming a symmetrical round-topped head and slender branchlets dull red and puberulous during their first season and dark gray-brown during their second year, and armed with stout straight spines from 1 1/2 to 2 in. in length.

Flowers in May. Fruit ripens late in October.

Rich woods, Allenton and Pacific, Missouri, *George W. Letterman*, May and October 1882.

This species, which was referred by Engelmann to *Crataegus tomentosa* Linnaeus, and to *Crataegus punctata* Jacquin, is still very imperfectly known. Its relationship appears to be with *Crataegus collina* Chapman, from which it differs in its more tomentose young leaves and branchlets, in its short thick-branched and more tomentose corymbs, ten stamens, rather larger fruit, and in its much later flowers.

**Crataegus Arnoldiana,** n. sp.— Leaves broadly ovate or rarely oval, acute at the apex, rounded, truncate or occasionally broadly cuneate at the base, irregularly divided above the middle into numerous short acute lobes, coarsely doubly glandular-serrate except at the base; in early spring densely villose above and below, and at maturity from 2 to 3 in. long and broad, membranaceous, smooth, dark green and lustrous on the upper surface, paler on the lower surface, slightly villose on the under side of the slender midribs and thin remote primary veins running to the points of the lobes and faintly impressed above; petioles slender, only slightly grooved, densely villose, ultimately puberulous, from 3/4 to 1 1/2 in. long; stipules linear, coarsely glandular-serrate, often 1 in. long, caducous. Flowers 3/4 in. in diameter on slender pedicels in broad loose compound many-flowered thin-branched tomentose cymes; bracts and bractlets lanceolate to oblanceolate, coarsely glandular-serrate;

calyx-tube broadly obconic, densely tomentose, the lobes narrow, elongated, acuminate, glandular-serrate, villose on both surfaces, reflexed after anthesis; stamens 10; filaments slender; anthers large, pale yellow; styles 3–5, usually 3 or 4, surrounded at the base by a broad ring of thick white tomentum. Fruit on slender pedicels in erect, spreading or sometimes drooping few-fruited slightly villose clusters, subglobose but rather longer than broad, bright crimson, marked by numerous large pale lenticels, villose particularly toward the ends with long white scattered hairs, ¾ in. long; calyx-cavity broad and shallow, the lobes coarsely glandular-serrate, villose, widespreading, often deciduous before the falling of the fruit; flesh thick, bright yellow, subacid; nutlets usually 3 or 4, thick, light-colored, prominently ridged on the back with high rounded ridges, about ¼ in. long.

A tree 15 to 20 ft. in height with a short trunk 10 or 12 in. in diameter, stout ascending branches forming a broad open irregular head, and slender strongly zigzag branchlets marked by large oblong pale lenticels, coated when they first appear with long matted hairs, becoming dark orange-brown and lustrous before midsummer and glabrous or puberulous during their first winter, light orange-brown and lustrous during their second season, and finally ashy-gray, and armed with very numerous stout straight or slightly curved bright chestnut-brown lustrous spines from 2½ to 3 in. long and brilliant for four or five years. Winter buds oblong, gradually narrowed to the obtuse apex, bright red and lustrous, about $\frac{3}{16}$ in. long.

Flowers during the last week of May. Fruit ripens by the middle of August and falls before the 1st of September.

Known in a wild state only in a small group of plants growing on a wooded bank in the Arnold Arboretum, but now frequently cultivated in the neighborhood of Boston, and in cultivation forming a tall trunk and promising to attain a large size.

When it is covered with its brilliant and abundant fruit *Crataegus Arnoldiana* is one of the most beautiful of the thorns which ripen their fruit in summer or early autumn. From *Crataegus submollis* (Sargent, BOT. GAZ.

31:7. 1901) of the same region it differs in its broader darker green more villose leaves which are usually rounded, not cuneate, at the base, in its smaller flowers, subglobose, not oblong or pear-shaped, crimson fruit with smaller spreading calyx-lobes, borne on shorter peduncles and ripening two or three weeks earlier, and by its much more zigzag and more spiny branches which make this tree particularly noticeable in winter when it may be readily recognized from all other thorn trees. From *Crataegus Champlainensis* (Sargent, Rhodora 3: 20), another of the eastern species of the *mollis* group with 10 stamens, it differs in its larger thinner leaves which are yellow-green, not blue-green, in its smaller subglobose, not oblong or obovate, early-ripening fruit, the fruit of *Crataegus Champlainensis* beginning to ripen early in September and remaining on the branches until midwinter. It differs also from this northern species in the form of the fruiting calyx and in its much more zigzag branchlets.

**Crataegus Arkansana,** n. sp. — Leaves oval to oblong-ovate, acute at the apex, broadly cuneate, or on vigorous leading shoots occasionally rounded at the base, usually divided above the middle into three or four pairs of short broad acute lobes, sharply serrate, sometimes to the very base, with spreading gland-tipped teeth; in early spring coated with short soft pale hairs, particularly on the under surface of the midribs and veins, and at maturity thick and leathery, dark dull green and glabrous on the upper surface, pale yellow-green on the lower surface, from 2 to 3 in. long, from 1¾ to 2 in. wide, or on vigorous shoots often 4 in. long and 3 in. broad, with stout light yellow midribs and primary veins deeply impressed above and slightly villose below with scattered pale hairs, conspicuous secondary veins and reticulate veinlets; petioles stout, deeply grooved, more or less winged above, glandular with minute usually deciduous dark glands, tomentose, ultimately glabrous or puberulous, usually dull red in the autumn, from 1 to 1½ in. long; stipules glandular-serrate, villose, linear-lanceolate to linear-obovate, about ½ in. in length. Flowers 1 in. in diameter in broad compound many-flowered thin-branched villose corymbs; bracts and bractlets oblong-ovate, acuminate, finely glandular-serrate; calyx-tube narrowly obconic, coated with long matted pale hairs, the lobes short, acute, very coarsely glandular-serrate, glabrous or slightly villose; stamens 20; filaments slender; anthers large,

pale yellow; styles 5. Fruit in few-fruited clusters, oblong or rarely obovate, full and rounded at the ends, bright crimson, lustrous, marked by few large dark lenticels, slightly tomentose at the ends, particularly at the apex, from ¾ to 1 in. long, ¾ in. thick; calyx-cavity deep but comparatively narrow, the lobes small, linear-lanceolate, coarsely glandular-serrate, red at the base on the upper surface, erect and persistent; flesh yellow, thick, dry, subacid; nutlets small in comparison with the size of the fruit, thin, rounded or slightly and irregularly ridged on the back, ⅓ in. long.

A tree from 15 to 20 ft. in height with a tall straight stem covered with pale scaly bark, thick ascending branches and stout slightly zigzag branchlets marked by large oblong pale lenticels, dark green and covered with long scattered pale hairs when they first appear, light orange-brown and very lustrous during their first winter, becoming ashy-gray during their second year, and unarmed or armed with occasional straight bright chestnut-brown spines gradually narrowed from broad bases and usually from ⅓ to ½ in. long. Winter-buds about ⅛ in. in length, nearly as broad as long, dark red, puberulous along the margins of the scales.

Flowers at the Arnold Arboretum about the middle of May. Fruit ripens at the end of October and remains on the branches for several weeks longer, falling gradually. Late in October or early in November the leaves turn bright clear yellow.

Apparently common in southern Arkansas (*B. F. Bush* 953), but first distinguished from plants in the Arnold Arboretum raised from seeds collected in 1883 by *George W. Letterman* at Newport, Ark.

From *Crataegus mollis* Scheele, with which it has been confounded, *Crataegus Arkansana* differs in the form and particularly in the leathery texture of the leaves which when young are villose, not tomentose, in its villose corymbs, its oblong late-ripening fruit, the fruit of *Crataegus mollis* falling from the middle of August to the middle of September, and in its unarmed or only slightly armed branchlets. Perfectly hardy in the Arnold Arboretum, *Crataegus Arkansana* is unsurpassed late in the autumn in the beauty of its large brilliant and abundant fruits which make it one of the most desirable garden plants of the genus.

**Crataegus Texana** Buckley, *Proc. Phil. Acad.* **1861**: 454.— Leaves broadly ovate, acute or rarely rounded at the apex, cuneate or on leading shoots truncate or slightly cordate at the base, usually divided above the middle into four or five pairs of broad acute lobes, very coarsely and doubly glandular-serrate except toward the base; when they first unfold covered above with short soft pale hairs and below with a thick coat of hoary tomentum, and at maturity thick and firm in texture, dark green and lustrous on the upper surface, pale and pubescent or tomentose on the lower surface particularly along the stout light-colored midribs and primary veins, and on the conspicuous secondary veins and reticulate veinlets, from 3 to 4 in. long, from 2½ to 3 in. wide; petioles stout, more or less winged above, deeply grooved, tomentose, ultimately nearly glabrous, from ½ to ¾ in. long; stipules lunate, apiculate, often stipitate, coarsely serrate, from ¼ to ½ in. long. Flowers ¾ in. in diameter on elongated slender pedicels in broad loose many-flowered tomentose cymes; bracts and bractlets oblong to oblong-ovate, broad, acuminate, villose, sometimes ½ in. long, very conspicuous; calyx-tube broadly obconic, coated with thick pale tomentum, the lobes gradually rounded from broad bases, acuminate, very coarsely glandular-serrate, villose with long matted hairs, reflexed after anthesis; stamens 20; filaments slender; anthers large, dark red; styles 5. Fruit in broad drooping many-fruited tomentose ultimately nearly glabrous clusters, short-oblong or somewhat obovate, full and rounded at the ends, tomentose until nearly fully grown, at maturity bright scarlet, lustrous, marked by occasional large pale lenticels, puberulous toward the apex, from ¾ to 1 in. in length; calyx-cavity broad and deep, the lobes much enlarged, glandular-serrate, villose, dark red at the base on the upper side, usually erect, often deciduous; flesh thick, yellow, sweet and edible; nutlets 5, thick, slightly grooved on the back, from ⅓ to ¼ in. long.

A tree often 30 ft. in height with a tall trunk sometimes a foot in diameter covered with dark closely appressed scales, stout spreading branches forming a symmetrical round-topped

head, or on young trees upright and forming an open irregular crown, and comparatively slender slightly zigzag branchlets, dark bronze-green and villose when they first appear, soon becoming dull reddish-brown, lighter reddish-brown in their second season, and ultimately pale ashy-gray, and often unarmed, or armed with occasional slender nearly straight bright chestnut-brown spines usually about 2 in. in length.

Flowers the middle of March. Fruit ripens toward the end of October.

Rich bottom-lands, central and western Texas.

Long confounded with *Crataegus mollis* Scheele (see Gray, *Proc. Phil. Acad.* 1867: 163), it can be distinguished from that species by the shape of the thinner leaves which are nearly always cuneate and only rarely cordate at the base even on the most vigorous shoots, and are usually less deeply lobed and much more coarsely serrate, by the smaller flowers in fewer-flowered more tomentose cymes, by the late-ripening fruit, and by the color of the branchlets and their more numerous spines. *Crataegus mollis* apparently does not extend south of central Missouri and middle Tennessee, being replaced in southern Missouri and Arkansas by several forms of the Mollis group which are still imperfectly known.

**Crataegus pedicellata,** n. sp.—Leaves broadly ovate, oval, or occasionally obvate or rhomboidal, acute or acuminate, broadly cuneate or rounded, and on vigorous leading shoots occasionally truncate or slightly cordate at the base, divided above the middle into four or five pairs of short acuminate lobes, coarsely and often doubly serrate, except toward the base, with spreading glandular teeth; in early spring roughened above by short rigid pale hairs and at maturity membranaceous, dark rich green and scabrate on the upper surface, pale and glaucous below, from 3 to 4 in. long, from 2 to 3 in wide, with slender midribs slightly impressed above and thin remote primary veins arching to the points of the lobes; petioles slender, only slightly grooved, villose but ultimately glabrous, obscurely glandular with minute scattered dark glands, from 1½ to 2 in. in length; stipules of leading shoots strongly falcate, stipitate, coarsely glandular-serrate, ⅓ in. long. Flowers ½ in. in diameter on slender-elongated pedicels, in loose lax rather few-flowered slender-branched

slightly villose corymbs; bracts and bractlets laciniate, glandular-serrate, caducous; calyx-tube narrowly obconic, glabrous, the lobes broad, acute, very coarsely glandular-serrate reflexed after anthesis; stamens 10; filaments slender, elongated; anthers rose color; styles 5, surrounded at the base by a conspicuous ring of pale tomentum. Fruit in few-fruited drooping glabrous clusters, oblong, full and rounded at the ends, bright scarlet, lustrous, marked by numerous small dark lenticels ¾ in. long, from ½ to ⅝ in. thick; calyx-cavity broad and deep, the lobes much enlarged, coarsely serrate, usually erect and incurved; flesh thin and pale; nutlets 5, rounded and deeply grooved on the back, ⅓ in. long.

A tree from 18 to 20 ft. in height with a stout trunk a foot in diameter and short ascending branches forming a broad open shapely head, and rather slender slightly zigzag branchlets marked by numerous small pale lenticels, dark chestnut-brown and slightly villose when they first appear, becoming bright chestnut-brown and very lustrous during their first season and ashy-gray during their second year, and armed with few stout straight or slightly curved chestnut-brown lustrous spines from 1½ to 2 in. long. Winter-buds nearly globose, bright red, very lustrous, ⅛ in. in diameter.

Flowers during the last week of May. Fruit ripens and mostly falls during the second half of September.

Rochester, N. Y., *C. C. Laney* and *John Dunbar*, 1899 and 1900.

This handsome tree is most conveniently placed in the *Flabellatae* group with *Crataegus Holmesiana* Ashe. From that species it differs in its larger darker green and more scabrous mature leaves, in its more lax villose corymbs, larger flowers on longer pedicels, with coarsely glandular-serrate calyx-lobes, more numerous stamens and styles, and in its larger and later-ripening fruit.

**Crataegus lucorum,** n. sp.— Leaves broadly ovate to obovate or rarely oval, acute or acuminate, gradually narrowed and full and rounded or broadly cuneate at the base, deeply divided above the middle into three or four pairs of broad acute or acuminate lobes,

dentate, except at the very base, with straight glandular teeth; when the flowers open not more than one third grown, bronze color, covered above with short soft pale hairs, glabrous below, and at maturity membranaceous, smooth dull dark green and glabrous on the upper surface, pale yellow-green on the lower surface, from 1½ to 2 in. long and broad, with slender yellow midribs slightly impressed above and thin primary veins running obliquely to the points of the lobes; petioles very slender, often short-winged above, nearly terete below, glandular, from 1 to 1½ in. in length; stipules lanceolate to oblanceolate, finely glandular-serrate, from ¼ to ½ in. in length, caducous. Flowers ¾ in. in diameter on slender pedicels in narrow compact few-flowered thin-branched slightly villose corymbs; bracts and bractlets linear-lanceolate, glandular, caducous; calyx-tube broadly obconic, glabrous, the lobes narrow, acuminate, conspicuously glandular-serrate, villose on the upper surface, reflexed after anthesis; stamens 20; filaments slender; anthers small, dark purple; styles 4 or 5. Fruit in erect few-fruited slightly villose clusters, pear-shaped until nearly fully grown, but at maturity oblong or somewhat obovate, full and rounded at the ends, crimson, lustrous, marked by small pale lenticels, from ½ to ⅝ in. long; calyx-cavity deep but narrow, the lobes elongated, glandular-serrate, villose above, spreading and closely appressed, often deciduous before the maturity of the fruit; flesh thick, yellow, dry, and mealy; nutlets 4 or 5, thin, rounded, and obscurely or not all ridged on the back from ½ to ⅝ in. in length.

A tree from 20 to 25 ft. in height, with a tall trunk from 6 to 8 in. in diameter covered with close dark red-brown bark, slender erect branches forming a narrow head and thin slightly zigzag branchlets marked by numerous oblong pale lenticels, dark green and slightly villose when they first appear, dull orange-brown in their first season, ultimately dark gray-brown, and armed with occasional straight or slightly curved bright red-brown spines from 1 to 1½ in. in length.

Flowers during the first week of May. Fruit ripens about the middle of September and soon falls.

Margins of oak groves in rich moist soil along the banks of sloughs near Barrington, Illinois, *E. J. Hill*, May and June 1899; *Hill* and *Sargent*, September 1900.

Distinguished from the other species in the *Tenuifoliae* group now recognized by it more numerous stamens.

**Crataegus Columbiana,** n. sp.—Leaves oval to obovate, or on vigorous shoots often broadly ovate to oblong-oval, usually acute, or occasionally rounded at the apex, full and rounded or gradually narrowed or abruptly cuneate at the base, irregularly doubly glandular-serrate, except toward the base, with broad spreading teeth; on leading shoots sometimes slightly divided above the middle into three or four pairs of short acute lobes; when they unfold conspicuously plicate, covered above with long soft white hairs and below with a thick coat of snow-white tomentum, and at maturity thin but firm in texture, dark green, lustrous and scabrate on the upper surface, paler and pubescent or tomentose on the lower surface, from 2 to 2½ in. long and broad, and on leading shoots often from 2 to 4 in. long and broad, with slender midribs, few thin primary veins and conspicuous reticulate veinlets; petioles stout, tomentose, about ½ in. long; stipules lunate, often apiculate, more or less stipitate, often coarsely glandular serrate, villose, from ¼ to ½ in. long. Flower ¾ in. in diameter on slender elongated pedicels covered with hoary tomentum like the slender branches of the broad lax many-flowered compound corymbs; bracts and bractlets oblong-obovate, acute or rounded and apiculate at the apex, finely glandular-serrate, slightly villose; calyx-tube narrow, obconic, coated with thick hoary tomentum, the lobes short, acute, coarsely glandular-serrate, tomentose on both surfaces; stamens 20, filament slender, elongated; anthers small, dark red; styles 5, surrounded at the base by long tufts of snow white hairs. Fruit in few-fruited spreading tomentose clusters, subglobose, often rather longer than broad, full and rounded at the ends, tomentose until nearly grown, dark red, marked by numerous large pale dots, glabrous at maturity, from ⅜ to nearly ½ in. in diameter; calyx-tube prominent, with a broad deep cavity, the lobes short,

spreading, usually deciduous before the ripening of the fruit; flesh thin, light-colored, hard, and dry, shrivelling on the branches; nutlets 5, rounded and usually ridged on the back, about ¼ in. long.

A tree 25 ft. in height, with a tall trunk from 6 to 8 in. in diameter covered with pale closely appressed scales becoming dark brown near the base of old individuals, and numerous upright branches often forming a broad symmetrical head, and slender slightly zigzag branchlets coated when they first appear with hoary deciduous tomentum, light reddish-brown and more or less villose during their first season, becoming rather darker during their second year and ultimately pale ashy-gray, and armed with numerous stout straight or slightly curved chestnut-brown lustrous spines usually from 1 to 1¼ in. in length.

Flowers toward the end of March. Fruit ripens after the middle of October and sometimes does not entirely fall until the following spring.

Sandy bottom-lands of the Brazos river, usually in open forests of live oaks at Columbia, Texas, *B. F. Bush*, November 1899; *Canby*, *Bush*, and *Sargent*, March 1900; *Bush*, April and October 1900.

**Crataegus Berlandieri,** n. sp.— Leaves oblong-obovate to oval, acute or acuminate at the apex, gradually narrowed below from near the middle and cuneate and entire at the base, irregularly divided into numerous acute or acuminate or, on vigorous shoots, rounded lobes, coarsely and often doubly serrate with broad spreading or incurved gland-tipped teeth; at the flowering time coated above with short pale soft caducous hairs and below with thick hoary tomentum, and at maturity rather thin but firm in texture, glabrous, dark green and very lustrous on the upper surface, pale and pubescent below, usually about 3 in. long and 2 in. wide, and on leading shoots often 4 or 5 in. long and from 2½ to 2 in. wide, with slender midribs and remote primary veins slightly impressed above and conspicuous secondary veins and reticulate veinlets; petioles stout, usually more or less winged above, tomentose, ultimately pubescent, from ½ to ¾ in. long;

stipules villose, falcate or on vigorous shoots lunate, coarsely glandular-serrate and frequently ½ in. in length. Flowers ¾ in. in diameter on stout elongated pedicels coated with hoary tomentum like the stout branches of the broad compound many-flowered cymes becoming lax after anthesis; bracts and bractlets oblong-obovate to lanceolate, finely glandular-serrate, conspicuous; calyx-tube broadly obconic, tomentose, the lobes broad, acute, very coarsely glandular-serrate, villose on both surfaces; stamens 20, filaments slender, elongated; anthers small; styles 5, slender, surrounded at the base by small tufts of snowy white hairs. Fruit in lax drooping clusters, short-oblong to subglobose, scarlet, about ½ in. long; calyx-cavity broad and deep, the lobes enlarged, coarsely serrate; flesh thin, yellow, dry, and hard; nutlets 5, rounded but not ridged, and occasionally obscurely grooved on the back, about ¼ in. long.

A tree 15 to 20 ft. in height, with spreading branches forming a broad open head, and slender slightly zigzag branchlets coated when they first appear with hoary tomentum, becoming puberulous and dull reddish-brown during the summer and pale gray-brown and glabrous during their second year, and nearly unarmed or furnished with occasional straight spines 1 in. in length.

Flowers from the middle to the end of March. Fruit ripens after the middle of October.

"De Bejur à Austin, Avril 1828," and "Villa d'Austin frio de los Brazos, Maio 1828," *J. L. Berlandier*, nos. 356 and 267 in Herb. Gray; near the banks of the Brazos river at Columbia, Texas, *B F. Bush*, October 1899, March, April, and October 1900.

**Crataegus nitida,** n. sp. (*Crataegus viridis* var. *nitida* Britton & Brown, *Ill. Fl.* **2**: 242. 1897).—Glabrous with the exception of a few scattered pale caducous hairs on the upper side of the midribs of the unfolding leaves. Leaves lanceolate to oblong-obovate, acuminate at the apex, abruptly or gradually narrowed and cuneate at the entire base, coarsely glandular-serrate above with straight or incurved glandular teeth, more or less divided,

particularly on leading shoots, into two or three pairs of broad acute lobes; when they first unfold membranaceous, dark red, soon becoming green and lustrous, almost fully grown when the flowers open, and at maturity thick and coriaceous, dark green and very lustrous on the upper surface, pale and dull on the lower surface, from 2 to 3 in. long, from 1 to 1½ in. wide, and on vigorous shoots often from 4 to 5 in. long and from 2 to 2½ in. wide, with prominent midribs usually red on the lower side and few slender prominent primary veins slightly impressed above and usually running to the points of the lobes; petioles stout, grooved, more or less winged above by the decurrent bases of the blades, glandular particularly on vigorous shoots, from ½ to ¾ in. long; stipules on vigorous shoots lunate, stipitate, coarsely glandular-serrate, occasionally ½ in. in length. Flowers ¾ in. in diameter on slender elongated pedicels in broad compound very thin-branched many-flowered corymbs; calyx-tube narrowly obconic, the lobes narrow, acuminate, elongated, entire or sparingly and irregularly glandular-serrate, reflexed after anthesis; stamens 15 to 20; filaments slender; anthers small, pale yellow; styles 2 to 5. Fruit in many-fruited drooping clusters, oblong, dull brick red, pruinose with a slight glaucous bloom, marked by small dark lenticels, from ½ to ⅝ in. long, ⅓ in. thick; calyx-cavity deep and narrow, the lobes little enlarged, dark red near the base on the upper side, usually erect, often deciduous before the maturity of the fruit; flesh yellow, thick, dry, sweet, and mealy; nutlets 2 to 5, rounded and ridged on the back with a low broad rounded ridge, light-colored, about ¼ in. long.

A tree often 30 ft. in height with a tall trunk from 12 to 18 in. in diameter covered with close dark bark broken into thick plate-like scales, spreading lower and erect upper branches forming a broad open rather irregular head, and slender nearly straight branchlets, bright orange-brown and lustrous during their first and second seasons, becoming pale reddish-brown during their third year, and ultimately ashy-gray, and unarmed or armed with few straight slender bright chestnut-brown lustrous spines from 1 to 1½ in. in length.

Flowers early in May. Fruit ripens toward the end of October.

Rich woods on the drier parts of the bottom-lands of the Mississippi river opposite St. Louis. East St. Louis, Illinois, *G. W. Letterman*, June 10, 1881, and *H. Eggert*, 1882. Banks of Mississippi river, near Oquawka, Illinois, *H. N. Patterson*. In November 1882, Mr. Letterman collected specimens of a Crataegus at Prescott, Arkansas, which may possibly belong to this species but the specimens are too fragmentary to make the determination satisfactory.

In the Arnold Arboretum the flowers of *Crataegus nitida* open during the first week in June and the fruit ripens towards the end of October and falls gradually. At this season of the year it is a handsome object, the large leaves of the long vigorous shoots having gradually turned to a rich orange-yellow color through shades of bronze and orange-red, while the leaves on the shoots of lateral branchlets are still green and very lustrous and make a beautiful contrast with the abundant but rather dull-colored fruit.

This species, which was distinguished by Dr. Engelmann on its discovery as *Crataegus nitens* in herb. was not published by him. It has been variously considered a variety of *Crataegus viridis* L., and as a natural hybrid of that species and of *Crataegus Crus-galli* L. The supposition of a hybrid can probably be safely dismissed. The plants are too numerous and were formerly too generally distributed over the Mississippi bottoms near St. Louis to make such a supposition probable; and the seedlings of this tree raised at the Arnold Arboretum which flower and fruit freely every year show none of the variation found in the descendants of hybrids when these are fertile. From *Crataegus viridis* it differs in its larger and much thicker and more lustrous leaves, larger flowers, much larger oblong pruinose fruit, and in its dark close bark, the bark of *Crataegus viridis* being pale or often nearly white and covered with thin loose scales.

**Crataegus Brazoria,** n. sp.— Leaves oval to obovate, acute or acuminate at the apex, sharply wedge-shaped, or on leading shoots occasionally oblong and usually broadly cuneate or sometimes rounded at the base, coarsely and irregularly glandular-serrate above the middle with spreading teeth, mostly entire below; when the flowers unfold covered on both surfaces with short soft pale hairs, particularly on the lower side of the thin midribs and primary veins, and at maturity thin and firm, glabrous, dark green and lustrous on the upper surface, paler on the

lower surface, from 2 to 2½ in. long, from 1¼ to 1½ in. wide, and on leading shoots often from 3 to 4 in. long and 3 in. wide; petioles slender, more or less winged above, tomentose, ultimately glabrous or puberulous, from ½ to ¾ in. long; stipules foliaceous, slightly falcate, acuminate, coarsely serrate, villose, long-stalked, from ⅓ to ½ in. long, often ⅓ in. wide, or on vigorous shoots lunate and usually entire. Flowers about ¾ in. in diameter in loose broad many-flowered compound thin-branched villose corymbs; calyx-tube narrowly obconic, villose with long matted white hairs, the lobes lanceolate, acuminate, obscurely glandular-serrate or nearly entire, villose on both surfaces, reflexed after anthesis; stamens 20; filaments slender, elongated; anthers small, dark red; styles 5, surrounded at the base by a thin ring of hoary tomentum. Fruit in spreading or drooping few-fruited glabrous clusters, subglobose or often rather longer than broad, bright canary-yellow, marked by a few large dark lenticels about ⅓ in. long; calyx-tube elongated, with a broad deep cavity, the lobes deciduous before the maturity of the fruit; flesh thin, light-colored, dry and mealy; nutlets 5, rounded and ridged on the back, about ¼ in. long.

Flowers from the middle to the end of March. Fruit ripens after the 1st of October.

A tree 20 ft. in height with a trunk 6 in. in diameter and 8 ft. tall with ashy gray bark covered with small closely appressed scales, numerous upright branches forming a handsome symmetrical round-topped head and slender slightly zigzag branchlets marked by small oblong pale lenticels, coated when they first appear with hoary tomentum, soon becoming glabrous and light reddish-brown, and ashy-gray during their second year, and apparently unarmed.

Still known only from a single individual growing by the roadside in the bottoms of the Brazos river in the town of Brazoria, Texas, where it was found on March 25, 1900, by *W. M. Canby*, *B. F. Bush*, and *C. S. Sargent*, and subsequently visited by Mr. Bush in April and October, 1900.

This very distinct and interesting species can perhaps be best grouped with *Crataegus viridis* Linn. From that species it differs in its larger flowers, in the bright canary-colored fruits, unlike in color those produced by any of the North American species now known, in the form and texture of the leaves and in the color of the bark of the trunk and branchlets.

**Crataegus glabriuscula,** n. sp. Glabrous with the exception of a few soft caducous hairs on the under surface of the large leaves of vigorous shoots and on the upper side of the calyx-lobes. Leaves oblong-ovate to semi-orbicular, or to broadly ovate on vigorous shoots, rounded, acute, or short-pointed at the apex, cuneate from below the middle and decurrent on the slender often glandular petioles, coarsely doubly serrate except toward the base, occasionally more or less deeply lobed above the middle, particularly on vigorous shoots, with two or three pairs of short broad acute lobes, membranaceous at the flowering time but at maturity subcoriaceous, hard and firm, dark green and lustrous on the upper surface, pale on the lower surface, from 1½ to 2 in. long, from ¾ to ½ in. wide, with slender pale yellow midribs and primary veins running obliquely toward the apex of the leaf, conspicuous secondary veins and reticulate veinlets; stipules lunate to semiorbicular, coarsely glandular serrate, from ⅓ to ½ in. wide, Flowers ½ in. in diameter on slender elongated pedicels, in few-flowered rather compact compound thin branched corymbs; bracts and bractlets linear, obscurely glandular-serrate, minute, caducous; calyx-tube broadly obconic, the lobes short, acute, entire or slightly and irregularly glandular-serrate, reflexed after anthesis; stamens 20; filaments slender, elongated; anthers comparatively large; styles 5. Fruit drooping on slender stems, oblong to obovate, dull orange-color, marked by minute dark lenticels, ¼ in. long; calyx-tube elongated with a deep broad cavity, the lobes but little enlarged, dull red on the upper surface toward the base, spreading or appressed, often deciduous; flesh very thin, yellow, dry and hard; nutlets 5, rounded or obscurely grooved on the back, about $\frac{3}{16}$ in. long.

A tree 20 to 25 ft. in height with a slender trunk often 12

in. in diameter, covered with brown scaly bark, ascending branches, forming a narrow head, and thin branchlets marked by many small pale lenticels, dark red-brown when they first appear, becoming bright chestnut-brown and very lustrous during their first summer and ashy-gray during their second year, and unarmed or armed with very slender straight chestnut-brown lustrous spines usually from ¾ to 1 in. in length.

Flowers about the middle of April. Fruit ripens in August. High dry bottom lands of the Trinity river and its branches at Dallas, Texas, in forests of *Ulmus crassifolia* and *Celtis Mississippiensis*, *J. Reverchon*, July 1899, *B. F. Bush*, April 1900.

**Betula Alaskana,** n. sp.—Leaves rhomboidal to broadly ovate and truncate or rounded at the base, acuminate, very coarsely dentate above the middle with glandular teeth, entire below, more or less covered with resinous glands while young, from 1½ to 3 in. long, from 1 to 1½ in. wide, dark green on the upper surface, yellow-green on the lower surface, the slender midribs and remote veins puberulous below or ultimately glabrous. Staminate catkins clustered, sessile, about 1 in. long, ⅛ in. thick, their scales ovate; acuminate, puberulous, light red, yellow on the margins. Pistillate catkins slender, cylindrical, pedunculate, about 1 in. long and ⅛ in. thick. Fruiting catkins from 1 to 1¼ in. long, from ⅓ to ½ in. thick, their scales about as long as broad, ciliate on the margins of the lobes, the central lobe acute or acuminate, the lateral lobes erect and acute or spreading and rounded.

A tree with close light red bark, usually from 35 to 40 ft. in height with a trunk 6 or 8 in in diameter, and occasionally 50 ft. in height with a trunk a foot in diameter, spreading and pendulous branches, slender red-brown branchlets more or less verrucose with conspicuous resinous glands, and obovate obtuse winter buds ¼ in. in length.

Saskatchewan, *E. Bourgeau*, 1858 (in Herb. Gray); near Prince Albert in latitude 53, July 1876, *John Macoun;* northwestward, reaching the Alaskan coast on the shores of the Lynn Canal (*Muir*, *Canby*, and *Sargent*, August 1897); and westward.

This is the "canoe birch" of all travelers in Alaska, and it is the common birch tree of the Yukon valley, where it grows sparingly near the banks of that river in coniferous forests and abundantly on sunny slopes and hillsides, and extends down the river at least as far as the Russian mission, two hundred and thirty-three miles above its mouth (M. W. Gorman *in litt.*).

From *Betula papyrifera* Marsh, which is common in one of its forms in southern Alberta, northern Idaho, and Montana, and in the Blue mountain region of eastern Washington and Oregon, *Betula Alaskana* may be distinguished by the close reddish bark of the trunk which is less flexible and does not separate as easily into layers as the bark of the eastern canoe birch, by the much more verrucose branches, obtuse winter buds, rhomboidal long-pointed leaves, stouter fruiting catkins, and by the more habitually acute or acuminate central lobe of their scales. The specimen in Herb. Gray collected by Bourgeau in flower on the Saskatchewan was referred by Regel (*Bull. Mosc.* **18**: 398; *DC. Prodr.* **16**$^{2}$: 164) to his *Betula alba*, subspecies *verrucosa* δ *resinifera*, the Asiatic types of this variety being from Udskoi in eastern Siberia and from Transbaical. Specimens of the Alaska tree sent by me to the Herbarium of the Imperial Botanic Garden at St. Petersburg were pronounced, however, unlike any Asiatic species, and with the slight knowledge of the northern Asiatic species of Betula which we possess in this country it does not seem safe to follow Regel in uniting North American with Asiatic species. To Mr. Gorman I am indebted for very complete specimens of *Betula Alaskana* collected at different points on the Yukon in 1899, and for the first reliable information I have been able to obtain in regard to the trees of the Yukon valley and their distribution.

BETULA OCCIDENTALIS Hooker. There are three arborescent birches in the region between the eastern base of the Rocky mountains in the United States and the shores of Puget sound and British Columbia.

First, *Betula papyrifera* Marsh, in one of its forms which enters this region from the east and is not rare in northwestern Nebraska, northern Dakota, Idaho, and Montana, and reaches the mountains of eastern Oregon.

Second, the large tree which grows on the lower Fraser river, on the shores and islands of Puget sound, and on Vancouver island. This tree has reddish bark which is particularly noticeable on young plants, pubescent branchlets, acute winter-buds, leaves pubescent on the lower surface, and fruiting

catkins about 1¼ in. long and ½ in. thick, with scales longer than broad, the middle lobe being acuminate and much elongated. Specimens of this tree, which is perhaps the largest of all birch-trees, were first gathered on the shores of the straits of Fuca by Dr. John Scouler during his visit to the northwest coast in 1825–1827. These specimens were described by Hooker in his *Flora Boreali-Americana* as *Betula occidentalis*, although with them he united a specimen collected by Douglas in the interior but west of the Rocky mountains. The tree from the straits of Fuca appeared first in the description of *Betula occidentalis* which was evidently drawn principally from the specimen of that tree, and must be considered the type of Hooker's species, while the second specimen included in this description, collected by Douglas, is the Rocky mountain form of Betula papyrifera. In the shape of the leaves this species resembles some of the forms of *Betula papyrifera*. The bark, however, is very different from that of the eastern tree, and it is probably best to consider it a species.

Third, the half-shrubby dark-barked species with spreading gracefully drooping stems which ranges as far south as Colorado, Utah, and northern California. This plant was collected by Nuttall on the Sweetwater, one of the branches of the Platte, and was first described and figured by him as *Betula occidentalis* (*Sylva* 1 : 23. *pl.* 7). Torrey in the Botany of Fremont's Expedition repeats this error. This same species was also described and figured in *King's Rep.* (5 : 323. *pl. 35*) as *Betula occidentalis* by Watson who repeated his error in the *Botany of California*, and it is this plant which is described and figured as *Betula occidentalis* in my ninth volume of *The Silva of North America*, where an allusion only is made to the true *Betula occidentalis* of the coast in a note under *Betula papyrifera*. Nuttall found another small birch in the Rocky mountain region and on the plains of the Columbia which he described and figured as *Betula rhombifolia* in the first volume of his *Sylva* published in 1842. This plant, judging by one of Nuttall's original specimens in the Gray Herbarium, is the narrow-coned form of the plant described by

Nuttall as *Betula occidentalis*, which is common in eastern Oregon and Washington and eastward into Montana and Idaho. If the two forms, which seem to vary only in the thickness of the cones, are considered to belong to one species, this would have to bear Nuttall's name of *Betula rhombifolia*, if Tausch four years before had not used that name for an European species. Some of the specimens of this third species bear a strong resemblance to a fragmentary specimen of *Betula microphylla* Bunge, as pointed out to me by Mr. M. L. Fernald, but this evidence of the identity of the Rocky mountain and the Altai plants would hardly seem to warrant the adoption of Bunge's name for our tree, for which I now propose the name of **Betula fontinalis.**

**Cupressus pygmaea,** n. sp. (*Cupressus Goveniana* var. *pygmaea* Lemmon, *Handbook West-American Cone-bearers* 77. 1895. *Cupressus Goveniana* Sargent, *Silva, N. Am.* **10**: 107 in part (not Gordon). 1896.—The Cupressus of the coast region of Mendocino county, California, can be readily distinguished from the other North American species by its thin black seeds not more than ⅛ in. long which show no tendency to vary to the thick light red seeds of *Cupressus Goveniana* which are fully ¼ in. in length. This character and the isolation of the region which it inhabits remote from that occupied by other species make it possible and convenient to separate this northern tree from the *Cupressus Goveniana* of central and southern California, to which it was doubtfully referred by Englemann in herb. who, like myself when the tenth volume of *The Silva of North America* was published in 1896, was unacquainted with the seeds. From *Cupressus Goveniana* the northern tree differs also in its rather stouter branchlets with deeper green never glaucous foliage, usually sessile often oblong cones with less prominent bosses on their scales which vary from six to ten in number, while the cones of *Cupressus Goveniana* are usually composed of six scales. In a genus like Cupressus where individuals vary greatly within certain limits and good specific characters are so difficult to find, these peculiarities would hardly justify the separation of the northern tree from *Cupressus Goveniana* were it not for the

character found in the seeds which make this the easiest of our species to recognize.

*Cupressus pygmaea* inhabits the high barren region on the coast of Mendocino county, extending from Ten Mile run on the north to the Navarro on the south, and, beginning about three quarters of a mile from the ocean, does not extend inland more than four miles. The soil of these barrens is yellow clay covered with deposits of sea sand and a thin layer of peat. On this poor soil the plants begin to bear cones when only a foot or two high, but on the borders of the barrens and of the deep gullies which penetrate them where trees occasionally escape for several years the fires which constantly sweep over the region they grow in better soil to a height of 30 or 40 feet, but from overcrowding rarely develop the spreading branches peculiar to all species of Cupressus growing in abundant space.

The name *pygmaea* used by Lemmon to distinguish the dwarf plant stunted by overcrowding and insufficient nourishment is unfortunate as a specific name, for there is no difference between the smallest and the largest plants except in size; and it is probable that individuals of this species on the borders of the barrens, if they could be protected from fire, would in time grow to a large size, for the oldest plants now standing show no signs of maturity and none of them are believed to be much more than fifty years old (C. Purdy *in litt.*).

ARNOLD ARBORETUM.

# THE EFFECT OF HYDROCYANIC ACID GAS UPON GRAINS AND OTHER SEEDS.

C. O. TOWNSEND.

(WITH SIX FIGURES)

## INTRODUCTION.

THE experiments which form the basis of this paper were undertaken more than two years ago for the purpose of determining the effect of hydrocyanic acid gas upon the germination of seeds. The necessity for the work arose from the rapidly increasing use of this gas in the destruction of insect pests infesting stored grains and other seeds. Since these experiments were begun a number of the largest flour mills in this country and Canada have been fumigated for the destruction of insects without removing the thousands of bushels of grain stored in the mills, and likewise numerous barns and granaries filled with grain have been fumigated for the same purpose. Since the grain thus fumigated may be used either for seed or for food, it is important to know whether or not the germinating quality of the grain has been injured and whether grain thus treated would be injurious for food. A preliminary account of the experiment in regard to germination of seeds after treatment with hydrocyanic acid gas was read before the Botanical Section of the A. A. A. S. at the Columbus meeting and subsequently published.[1]

The use of hydrocyanic acid gas for fumigating purposes is of comparatively recent origin, having been introduced by the U. S. Department of Agriculture, Division of Entomology, in 1886, for the fumigation of orange trees. It was first used for the fumigation of greenhouses by Dr. A. F. Woods,[2] Director of the

[1] TOWNSEND: "The effect of hydrocyanic acid gas upon the germination of seeds." Sci. Amer. Suppl., no. 1248, 2 D. 1899.

[2] WOODS: The variable effects of hydrocyanic acid gas on plants and animals. Rep. Soc. Plant Morph. and Physiol., Am. Nat. 1899.

Division of Vegetable Physiology and Pathology, and even before it was used for fumigating purposes its effect in solution was determined by Dr. Loew.[3]

This gas has now come into universal use not only for the fumigation of trees and grains as above indicated, but also for the fumigation of greenhouses,[4] nursery stock, and even orchard trees of all kinds.[5]

The object of the writer in performing these experiments, the results of which are herein recorded, has been simply to determine whether or not hydrocyanic acid gas has any injurious effect upon grains or other seeds; and, if so, under what conditions and to what extent the injury is produced. Hence this paper is merely preliminary to the more minute study of the subject, since it deals only with the cause and effect, while the nature of the action of the poison upon the several parts of the seed still remains for further investigation.

In general the methods employed in these experiments have consisted simply in placing the seeds to be tested in air tight chambers in which hydrocyanic acid gas is generated. In the first experiments the chambers consisted of air tight boxes of several cubic feet capacity, used primarily for the fumigation of nursery stock. These boxes were open on one side, the open side being placed next the ground, which was first made perfectly smooth and level. In experimenting with these boxes, they were raised slightly on one edge, the material to be fumigated was placed under them, and at the moment the hydrocyanic acid gas was generated the boxes were lowered and sand quickly pressed around the edges next the ground, making them practically gas-tight. In these as in the subsequent experiments the gas was generated by placing cyanid of potassium (KCN) in dilute sulfuric acid ($H_2SO_4$), the result of the chemical action being the evolution of hydrocyanic acid gas (HCN) according

[3] LOEW: Natur. System der Giftworkung. Bull. Imp. Univ. Coll. Agr. 1: 34. 1893. The poisonous action of dicyanogen.

[4] WOODS and DORSETT: The use of hydrocyanic acid gas for fumigating greenhouses and cold frames. Circ. no. 37. Ser. 2, U. S. Dept. Agr., Div. Ent.

[5] JOHNSON: Report on the San José scale. Bull. 57, Md. Agr. Exper. Station. 1897.

to the following chemical equation: $2KCN + H_2SO_4 = 2HCN + K_2SO_4$. In the later experiments bell jars were used having a capacity of approximately one third of a cubic foot each (*fig.* 1). The bell jars were provided with ground glass stoppers, and were placed on ground glass plates, the edges being sealed with oil to prevent the escape of the gas. Having prepared the seeds in the manner desired, they were placed on the ground glass plate, and in a small beaker directly in the center of the plate was the dilute sulfuric acid, so that when the bell jar was placed in position the beaker containing the sulfuric acid was exactly below the glass stopper in the bell jar. The potassium cyanid was carefully weighed and wrapped in fine tissue paper. A piece of twine, just equal in length to the distance from the lower surface of the glass stopper in the bell jar to the bottom of the beaker containing the sulfuric acid, was tied to a package containing the desired weight of potassium cyanid, and the other end of the string was fastened by means of soft paraffin to the lower surface of the glass stopper of the bell jar. When everything was ready to begin the experiment the package of potassium cyanid attached to the string was lowered through the opening in the top of the bell jar, and just at the instant when this package came into contact with the dilute sulfuric acid the ground glass stopper fell into place and thus hermetically sealed the jar. By this means it was possible to keep the seeds for any required length of time in an atmosphere of hydrocyanic acid gas of desired strength. When the bell jars were opened, even after several months, the characteristic odor resembling peach kernels could be detected, showing that the gas had neither escaped nor been absorbed, although in at least some of the experiments a portion of the gas was probably absorbed, since it has a strong affinity for moisture. It should be borne in mind that both the potassium cyanid and the hydrocyanic acid gas are deadly poisons and great care should be exercised in using them. Potassium cyanid is a white solid and is on the market in several forms. It should be purchased for use in the lump form usually known as 98 per cent. cyanid of

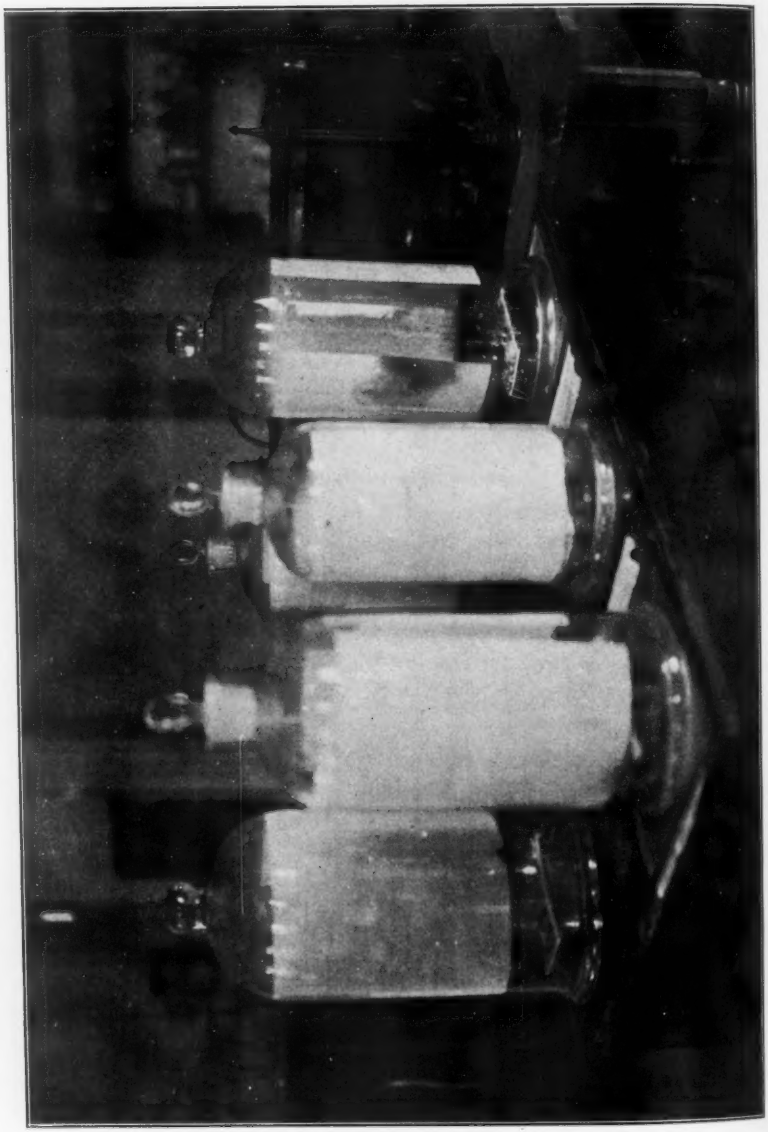


FIG. 1.—Bell jars in which the effect of hydrocyanic acid gas upon the germination of seeds is being determined.

potassium, and should be kept in air tight cans or jars until ready for use.

If the seeds were to be treated in the dry state, no moisture was added except what was used to dilute the acid, and this consisted of only a few cubic centimeters of water. On the other hand, if damp seeds were to be treated with hydrocyanic acid gas, they were first soaked for the desired length of time in water, and then placed on moist filter paper under the bell jar, which was lined with damp filter paper, thus providing for the seeds a moist atmosphere favorable for their germination. All the chambers, whether damp or dry, were kept in the general laboratory where a pretty constant temperature of about 18° C. was maintained. Further details in regard to methods can best be made clear by referring to the accompanying tables and their descriptions. The materials used in these experiments consisted for the most part of corn, wheat, beans, and clover seed. Occasionally other seeds were used in addition to those mentioned, but these four were carried through all the experiments and may be considered as fairly representing the seeds of monocotyledonous and dicotyledonous plants. Under certain conditions some of the seeds used seemed to be more sensitive to the treatment to which they were subjected than the others, but in general the behavior of the seeds under the conditions used was similar for all seeds under identical conditions, the difference being simply a matter of degree. In other words, if the effect of the treatment was to accelerate germination all the seeds germinated more quickly than under normal conditions, whereas if the effect of the treatment was to retard germination then all germinated less readily than under normal conditions, although all seeds of the same kind did not germinate at the same moment.

The strength of hydrocyanic acid gas used in these experiments is stated in terms of the weight per cubic feet of space to be fumigated of the cyanid of potassium used in generating the gas. In fumigating nursery stock for the destruction of insect pests, as well as for fumigating mills, barns, etc., 0.25$^{gm}$ of

FIG. 1.—Bell jars in which the effect of hydrocyanic acid gas upon the germination of seeds is being determined.

cyanid of potassium is used for each cubic foot of space to be fumigated.[6]

In these experiments the strength of the gas varied from 0.003$^{gm}$ per cubic foot to 1.45$^{gm}$ per cubic foot. While in the first experiments the object was simply to determine whether or not the ordinary strength of the gas used in fumigation would be harmful to the grain or other seeds, in the later experiments an effort was made to determine the maximum and minimum strength of gas that the seeds could resist under the several conditions employed. It should be noted that time is an important factor in these experiments. Nursery stock may be fumigated in thirty minutes, so that all insect life will be destroyed; but in fumigating buildings in which large bulks of grain are stored time must be allowed for the gas to penetrate the mass of grain and thus reach the insects that may be scattered through it. While time is being given for the gas to penetrate the bulk of grain, the grain on the surface of the bulk is exposed to the influence of the gas from the time it is generated. Hence an effort was made to determine the maximum and minimum time required for the grains to respond to the influence of the various strengths of gas used under the several conditions employed, and with this point in view the exposures varied from one hour to one year.

### EXPERIMENTS WITH DRY SEEDS.

*Trial experiments.*—In the first experiments dry seeds were placed in shallow dishes and exposed for one hour to charges of gas varying in strength from 0.25$^{gm}$ to 1.45$^{gm}$ of potassium cyanid per cubic foot. Only a thin layer of seeds was placed in each dish, so that the gas came directly into contact with each seed. At the end of one hour the seeds were taken from the fumigating chamber and placed in hydrant water for twenty-four hours. At the expiration of this time they were spread upon moist filter paper in damp chambers and kept at ordinary room temperature of about 18° C. In this, as in all the other tests, control experiments were used in which the seeds were treated in precisely

[6] JOHNSON, *loc. cit.*

the same manner and kept under exactly the same conditions as in the subsequent experiments, except that they were not subjected to the influence of the gas.

The first line in each table expresses the result of the control experiments for that particular set of experiments, so that in whatever manner the seeds under examination behaved it was clear that the variation in behavior from the seeds in the control experiments resulted entirely from the effect of the hydrocyanic acid gas.

In all cases it was found that the seeds that had been subjected to the gas for one hour germinated just as readily as if they had not been in the gas at all. Hence it may be concluded that perfectly dry seeds may be subjected for a short time to the influence of gas six times as strong as that ordinarily used in fumigation without any appreciable injury to the germinating quality of the seed.

TABLE I.

Dry seeds subjected to the influence of hydrocyanic acid gas, then soaked and placed under conditions favorable for germination; temperature 18° C.

| Amount of KCN per cubic foot | Time of exposure to gas | Time of soaking | Time required for germination | Percentage of germination | Subsequent growth of seedlings |
|---|---|---|---|---|---|
| 0.00 . . . | 1 hour | 24 hours | 24 hours | 100 | normal |
| 0.25 . . . | 1 " | 24 " | 24 " | 100 | " |
| 0.45 . . . | 1 " | 24 " | 24 " | 100 | " |
| 0.60 . . . | 1 " | 24 " | 24 " | 100 | " |
| 0.75 . . . | 1 " | 24 " | 24 " | 100 | " |
| 1.00 . . . | 1 " | 24 " | 24 " | 100 | " |
| 1.25 . . . | 1 " | 24 " | 24 " | 100 | " |
| 1.45 . . . | 1 " | 24 " | 24 " | 100 | " |

*Subsequent experiments.*—In the trial experiments the seeds were subjected to the influence of hydrocyanic acid gas for one hour only. In order to determine the influence of this gas upon seeds exposed for a long time, subsequent experiments with dry seeds were undertaken. The seeds were placed in shallow dishes which were covered by bell jars, made air tight, and the gas generated in the manner described. Control experiments were started at the same time, in which the seeds were covered by

bell jars under the same conditions as in the experiments, with the exception that no KCN was placed in the dilute sulfuric acid. The results are best expressed in the following table:

TABLE II.

Dry seeds treated with hydrocyanic acid gas for long periods of time: temperature throughout about 18° C.

| Amount of KCN per cubic foot | Time of exposure to gas | Time of soaking | Time required for germination | Percentage of germination | Subsequent growth of seedlings |
|---|---|---|---|---|---|
| 0.000 . . . | 0 | 24 hours | 24 hours | 100 | normal |
| 0.333 . . . | 15 days | 24 " | 12 " | 100 | accelerated |
| 1.000 . . . | 15 " | 24 " | 7 " | 100 | accelerated |
| 0.333 . . . | 60 " | 24 " | 9 " | 100 | accelerated |
| 1.000 . . . | 60 " | 24 " | 14 " | 100 | slightly retarded |
| 0.333 . . . | 153 " | 24 " | 30 " | 75 | slightly retarded |
| 1.000 . . . | 153 " | 24 " | 36 " | 60 | greatly retarded |
| 0.333 . . . | 240 " | 24 " | 76 " | 50 | retarded half |
| 1.000 . . . | 240 " | 24 " | 96 " | 10 | very slight |
| 0.333 . . . | 365 " | 24 " | 240 " | 20 | none |
| 1.000 . . . | 365 " | 24 " | no germination | 0 | |

From the foregoing table it will be seen that the seeds were constantly under the influence of the gas for from fifteen days to one year. The strength of the gas was constant in each jar, *i. e.*, it did not vary except possibly by the absorption of a small quantity of the gas into the seeds and into the few cubic centimeters of dilute acid used in generating the gas. It is surprising that the seeds should germinate more readily after they had been exposed to the gas for a few days, although the same phenomenon was observed in the action of ether upon the germination of seeds.[7]

At the expiration of sixty days the acceleration of germination had passed its maximum, and shortly after began to be retarded, until at the end of two hundred and forty days germination practically ceased for those seeds that were exposed to the gas from one gram of KCN per cubic foot (*fig. 2, c*). The seeds that were in the weaker charge of gas continued to

[7] TOWNSEND: The influence of ether upon the germination of seeds and spores. BOT. GAZ. **27**: 458. 1899.

germinate about four months longer, but that was evidently the limit, as only a few of the seeds germinated very feebly at the expiration of that time (*fig. 3, b*). Not only was the germination hastened, but the subsequent growth was likewise accelerated for a limited time. Although the subsequent growth of seedlings

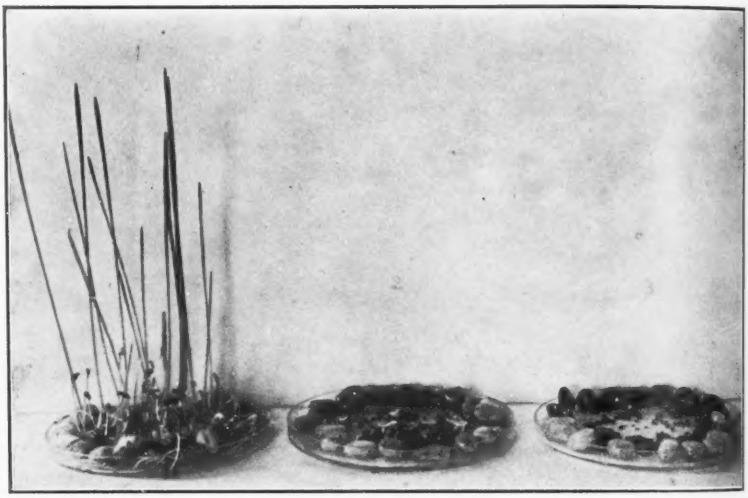
*a* *b* *c*

FIG. 2.—*a*, control; *b*, from seeds that were eight months in gas from 0.333$^{gm}$ KCN per cubic foot; *c*, seeds that were eight months in gas from 1$^{gm}$ KCN per cubic foot.

was in some instances very marked, being almost double that of the normal, this acceleration was of short duration, rarely lasting more than one week, and then gradually resuming the normal rate of growth. Hence the acceleration is probably not of sufficient duration to be of any commercial value.

It appears from these experiments that dry seeds may be treated with hydrocyanic acid gas continuously for several weeks without reducing the percentage of germination or interfering

seriously with the subsequent growth of the seedlings. It is clear, however, that the gas has a marked influence upon dry seeds. The extent of the influence depends upon the amount of gas per cubic foot and upon the time the seeds are subjected to its influence. After sixty days the percentage of germination



*a* *b* *c*

FIG. 3.—*a*, control; *b*, seeds that were one year in gas from 0.333$^{gm}$ KCN per cubic foot; *c*, seeds that were one year in gas from 1$^{gm}$ KCN per cubic foot.

was gradually reduced, and the subsequent growth of seedlings was likewise retarded. The greater reduction in the percentage of germination, as well as in retardation of growth, depended upon the length of time of exposure to the gas and upon the amount of gas present. At the end of eight months the seeds in the gas from one gram of KCN had practically lost their ability to germinate, since only one in ten was capable of even slight germination, and those were too feeble for subsequent growth (*fig. 2, c*). If the gas was generated from only one third of a gram of KCN per cubic foot, the seeds retained their ability to

germinate four months longer, or one year from the beginning of the experiment (*fig. 3, b*). In general it may be stated that the length of time that dry seeds retain their ability to germinate varies inversely with the strength of gas to which the seeds are subjected. Likewise the converse of this is true, viz., that the strength of gas that will prevent seeds from germinating varies inversely with the time that the seeds are subjected to the influence of the gas. These rules are stated only for the seeds that are subjected to the gas under the foregoing conditions, and will not apply with certainty to seeds under other conditions. It should be stated in this connection that the seeds in the control jar did not germinate quite normally either in percentage or point of time at the end of twelve months (*fig. 3, a*). To what this slight variation was due has not yet been determined, but it does not seem probable that it was sufficient to affect the results in the jars containing the gas. Seeds from the original packages not inclosed in a jar germinated normally, *i. e.*, 100 per cent. in twenty-four hours.

### EXPERIMENTS WITH MOIST SEEDS.

Since it may sometimes be necessary to fumigate grain or other seeds while in a moist condition, experiments were undertaken for the purpose of determining what effect hydrocyanic acid gas would have upon seeds that had been soaked for a longer or shorter time in water. After soaking the seeds the following conditions were observed, viz., the damp seeds were left to germinate in the gas which was of different strengths in different jars; they were then placed for a time in the gas of different strengths and then removed to a gas free atmosphere.

*Damp seeds allowed to remain in hydrocyanic acid gas.*— By referring to tables III, IV, and V it will be seen that the seeds were soaked for different lengths of time, and that they were subjected to atmospheres of gas of different strengths.

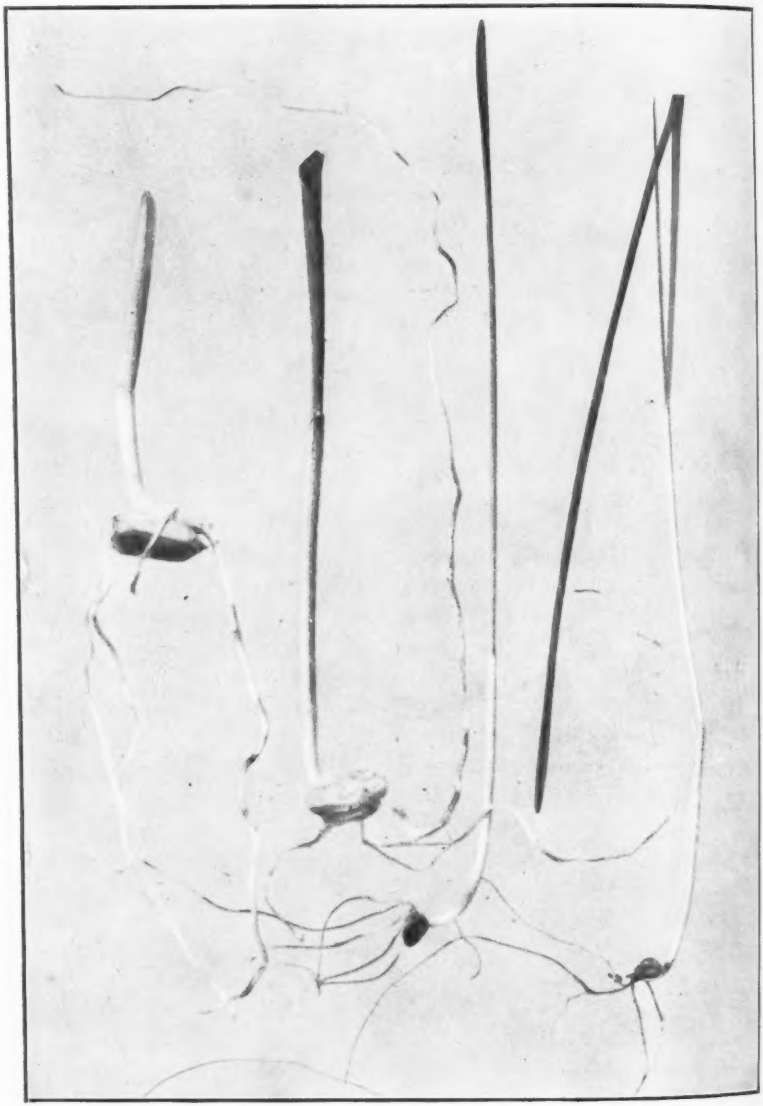


FIG. 4.—Corn and wheat seedlings. The larger one in each case is normal, while the smaller ones were from seeds treated eight months with gas from 0.333 gm KCN per cubic foot.

TABLE III.

Germination of damp seeds and subsequent growth of resulting seedlings in hydrocyanic acid gas; temperature throughout about 18° C.

| Amount of KCN per cubic foot | Time of soaking | Time required for germination | Percentage of germination | Subsequent growth of seedlings |
|---|---|---|---|---|
| 0.000 | 24 hours | 24 hours | 100 | normal |
| 0.003 | 24 " | 168 " | 90 | very slow |
| 0.010 | 24 " | no germination | 0 | .... |
| 0.050 | 24 " | no germination | 0 | .... |
| 0.060 | 24 " | no germination | 0 | .... |
| 0.075 | 24 " | no germination | 0 | .... |

It will be observed in table III that the amount of KCN used varied from 0.003 to 0.075$^{gm}$ per cubic foot, but that no germination took place if more than 0.003$^{gm}$ was used, and indeed in this strength of gas germination was delayed for six days. Other quantities of KCN between 0.003 and 0.010$^{gm}$ were used, but the seeds seemed to be unable to germinate in any charge stronger than 0.003$^{gm}$ per cubic foot. The subsequent growth of the seedlings in this very small amount of hydrocyanic acid gas was very slight, and did not exceed two inches in ten days, in some instances the growth being only a fraction of an inch.

TABLE IV.

Same as table III, except that the seeds were soaked for a shorter time before placing in the gas.

| Amount of KCN per cubic foot | Time of soaking | Time required for germination | Percentage of germination | Subsequent growth of seedlings |
|---|---|---|---|---|
| 0.000 | 12 hours | 24 hours | 100 | normal |
| 0.003 | 12 " | 36 " | 80 | slight |
| 0.010 | 12 " | 36 " | 40 | very slight |
| 0.050 | 12 " | 40 " | 20 | none |
| 0.060 | 12 " | no germination | 0 | .... |
| 0.075 | 12 " | " " | 0 | .... |

In the experiments recorded in table IV the seeds were soaked only twelve hours, but the control seeds germinated in practically the same time as in the preceding case where the seeds were soaked for twenty-four hours. It is also important to

note that the small charge of only 0.003$^{gm}$ of KCN retarded the germination but a few hours as compared with the retardation produced by the same charge of gas when the seeds were soaked for twenty-four hours. It is likewise a noteworthy fact that when the seeds were soaked but twelve hours they were much more resistant to the influence of hydrocyanic acid gas, as evidenced by the fact that at least a few of the seeds were able to germinate in as much as 0.050$^{gm}$ of KCN per cubic foot. The subsequent behavior of the seedlings was the same as in the preceding case, *i. e.*, there was little or no growth after the plant escaped from the seed coats. In general it was found that the shorter time the seeds were soaked the more resistant they were to the influence of the gas.

TABLE V.

Same as table III, except that the seeds were soaked for a longer time before placing in the gas.

| Amount of KCN per cubic foot | Time of soaking | Time required for germination | Percentage of germination | Subsequent growth of seedlings |
|---|---|---|---|---|
| 0.000 | 36 hours | 20 hours | 100 | normal |
| 0.003 | 36 " | 48 " | 60 | slight |
| 0.010 | 36 " | no germination | 0 | .... |
| 0.050 | 36 " | " " | 0 | .... |
| 0.060 | 36 " | " " | 0 | .... |
| 0.075 | 36 " | " " | 0 | .... |

In these experiments it will be seen that the extra amount of soaking caused the seeds to germinate more readily than they would have done had they been soaked but twenty-four hours, both in the case of the control experiments and in the experiments in which but 0.003$^{gm}$ of KCN was used. However, the seeds did not germinate as readily as they did when soaked but twelve hours, nor was the percentage of germination so high as in either of the preceding cases. It is probable that the germination took place more quickly than in the experiments recorded in table III, because the seeds were more advanced before they were removed from the water and placed in the gas. In all cases the seeds were extremely sensitive and made but very

slight growth after breaking through the seed coats. Leaving out of account the advance that the seeds made toward germination while they were in the water and before placing them in the gas, it appears that their sensitiveness increased with the length of time that they were allowed to soak. This is to be expected since hydrocyanic acid gas has a strong affinity for moisture and is readily absorbed by water.

*Seeds soaked for a definite time in water, placed for a given time in hydrocyanic acid gas, and then removed to a gas free atmosphere.*— When it was observed that the seeds which had been soaked and then placed in hydrocyanic acid gas germinated more slowly than under normal conditions, it was apparent that the seeds were being held in a dormant state for a longer or shorter time depending upon the length of time the seeds were soaked, upon the strength of gas used, and upon the length of time that the seeds were allowed to remain in the gas. In order to get more definite information in regard to this point, experiments were undertaken whose results are recorded in tables VI and VII.

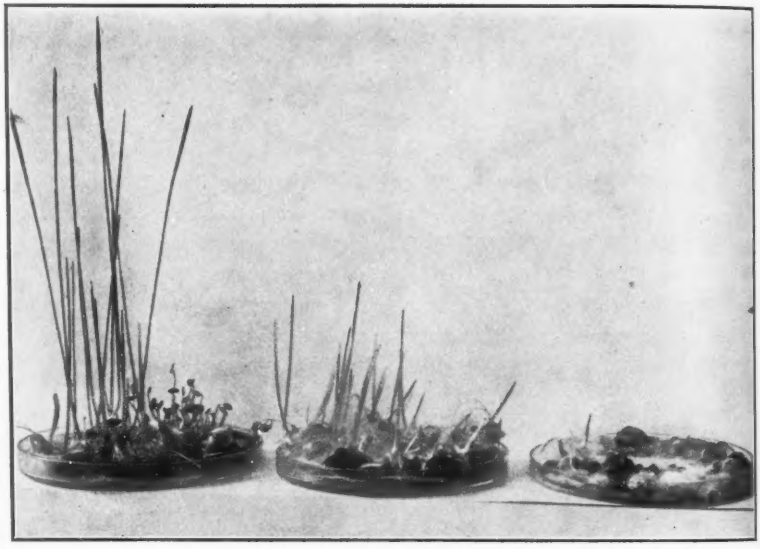
TABLE VI.

Germination of seeds and subsequent growth of seedlings after soaking in water, then placing for a definite time in hydrocyanic acid gas, and then removing to a gas free atmosphere; temperature 18° C.

| Amount of KCN per cubic foot | Time of soaking | Time of exposure to gas | Time required for germination | Percentage of germination | Subsequent growth of seedlings |
|---|---|---|---|---|---|
| 0.000 . . . | 24 hours | 0 | 24 hours | 100 | normal |
| 0.003 . . . | 24 " | 168 hours | already germ. | 90 | slow |
| 0.010 . . . | 24 " | 168 " | 168 hours | 50 | very slow |
| 0.050 . . . | 24 " | 168 " | 336 " | 20 | barely started |
| 0.060 . . . | 24 " | 168 " | no germination | 0 | .... |
| 0.120 . . . | 24 " | 168 " | " " | 0 | .... |

As shown in table III, seeds that have been soaked for twenty-four hours and then left for seven days or 168 hours in an atmosphere containing gas from 0.003$^{gm}$ of KCN per cubic feet were able at the end of that time to germinate without removing from the gas, while seeds subjected to a stronger charge of gas were unable to germinate in the gas. Hence the

experiments as recorded in table VI were undertaken. In these experiments the seeds were treated as in the experiments recorded in table III, except that at the end of seven days the seeds exposed to the gas from 0.010$^{gm}$ of KCN or more per cubic foot were removed from the gas and placed in a gas free atmosphere.



*a* *b* *c*

FIG. 5.—*a*, control; *b*, seeds were in gas from .030$^{gm}$ KCN per cubic foot for 168 hours; *c*, seeds were in gas from .010$^{gm}$ KCN per cubic foot for 168 days.—Photographed at end of 18 days. See table VI.

At the end of seven days, after placing the seeds in ordinary atmosphere, 50 per cent. of those that had been exposed to the gas from 0.010 of KCN germinated. In other words, the seeds that germinated had been held in a dormant condition for seven days in the gas and for seven days after removing from the gas, a total of fourteen days. Likewise seeds that had been in the gas from 0.050$^{gm}$ of KCN per cubic foot were held in a dormant condition for twenty days. In the preceding case only five

seeds out of every ten germinated, while in the latter instance only two seeds out of every ten germinated. Hence it should be noted that much depends upon the natural vitality of the seeds, not only in these experiments but in all cases where seeds are subjected to similar treatment. If the seeds were subjected for seven days to a charge of gas greater than that produced from 0.050$^{gm}$ of KCN per cubic foot, they were unable to germinate in a single instance. In those cases where germination did take place, the subsequent growth of the seedlings was always slow and feeble. It is true that some of the seedlings, in these as well as in other experiments where the subsequent growth was slow, were able to overcome the influence of the gas after a longer or shorter time and to grow at the normal rate.

Since the seeds subjected to the gas from more than 0.050$^{gm}$ of KCN per cubic foot were unable to germinate, it was decided to test the effect of a comparatively strong charge of the gas for a short time. The results of these experiments are recorded in table VII.

TABLE VII.

Same as table VI, except that a stronger charge of hydrocyanic acid gas was used for a short time.

| Amt. of KCN per cubic foot | Time of soaking | Time of exposure to gas | Time required for germination | Percentage of germination | Subsequent growth of seedlings |
|---|---|---|---|---|---|
| 0.000 . . | 24 hours | 0 | 24 hours | 100 | normal |
| 0.250 . . | 24 " | 3 hours | 72 " | 50 | " |
| 0.250 . . | 24 " | 6 " | no germination | 0 | .... |
| 0.250 . . | 24 " | 12 " | " " | 0 | .... |

In these experiments it was found that some of the seeds were able to resist for more than three hours the influence of the gas from 0.25$^{gm}$ of KCN per cubic foot, although after three hours one half the seeds were unable to germinate and the other half were held in check for seventy-two hours or forty-eight hours beyond the usual time of germination. However, the seeds that did germinate produced seedlings that grew at the normal rate.

*Seeds soaked, treated with gas, washed and placed in HCN-free atmosphere.*— The experiments recorded in table VIII were

undertaken in order to determine whether the hydrocyanic acid gas that retarded germination after the seeds were removed from the atmosphere of the gas remained in the moisture that adhered to the seeds, whether the gas was primarily absorbed by the seeds, or whether retardation was simply an after effect of the gas upon the seeds.

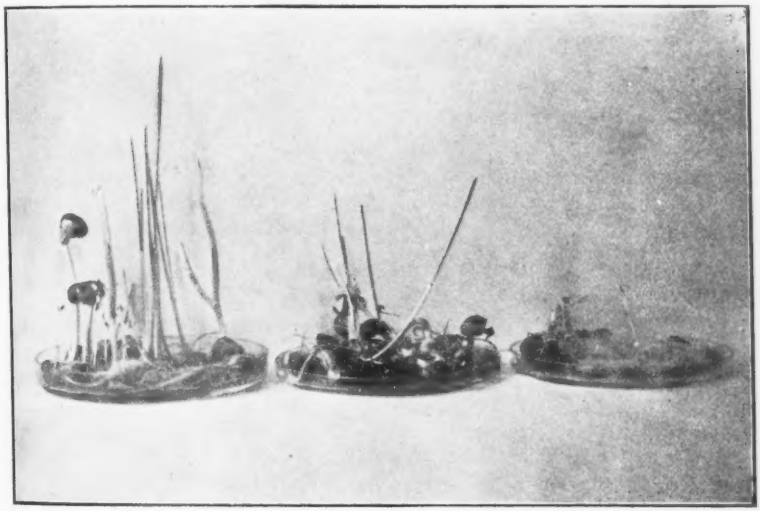
TABLE VIII.

Seeds soaked, placed for a definite time in hydrocyanic acid gas, then washed and placed in an atmosphere free from hydrocyanic acid gas; temperature throughout experiment about 18° C.

| Amt. of KCN per cubic foot | Time of soaking | Time of exposure to gas | Subsequent treatment | Time required for germination | Percentage of germination | Subsequent growth of seedlings |
|---|---|---|---|---|---|---|
| 0.000 . | 24 hours | 0 | { placed in pure air } | 24 hours | 100 | normal |
| 0.100 . | 24 " | 6 hours | washed | 72 " | 100 | " |
| 0.100 . | 24 " | 6 " | not washed | 96 " | 50 | ¾ nat. size |
| 0.250 . | 24 " | 6 " | washed | 144 " | 100 | normal |
| 0.250 . | 24 " | 6 " | not washed | no germ. | 0 | .... |
| 0.250 . | 24 " | 18 " | washed | 168 hours | 60 | ½ nat. size |
| 0.250 . | 24 " | 24 " | washed | 240 " | 10 | slight |
| 0.250 . | 24 " | 48 " | washed | no germ. | 0 | .... |

It is apparent that more or less of the hydrocyanic acid gas remains in the film of water that adheres to and surrounds the seeds after they are removed from the gas, since they germinate much more readily after washing. It should be noted that the washing did not consist in soaking the seeds but simply rinsing them under the hydrant. If the seeds were not washed they were unable to germinate after six hours in the gas from $0.250^{gm}$ of KCN per cubic foot, whereas the seeds were able to germinate after eighteen hours in the gas, providing they were washed immediately after removal. If they were exposed to the same charge of gas, viz., $0.250^{gm}$ of KCN per cubic feet for twenty-four hours or more, they were unable to germinate even when they were thoroughly washed after removing from the gas. It would seem from the experiments that more or less of this poisonous gas remains in the moisture that surrounds the seeds, and that the gas clings to the damp surface of exposed seeds. If the gas is not removed by washing it seems to have a strong

affinity for moisture and for the seed, and eventually penetrates the seed even after the treated seeds have been exposed to the ordinary atmosphere. However, not all of the gas remains on the outer surface of the seed nor in the moisture sorrounding it, since a marked influence of the gas could be observed in those seeds that were first treated with the gas and then washed.



*a* *b* *c*

FIG. 6.—*a*, seeds in gas from 0.10$^{gm}$ KCN per cubic foot for six hours, then washed and placed in gas-free atmosphere; growth practically normal; *b*, seed in gas from 0.25$^{gm}$ KCN for eighteen hours, then washed and placed in gas-free atmosphere; *c*, seeds in gas from 0.25$^{gm}$ KCN per cubic foot for twenty-four hours, then washed and placed in gas-free atmosphere.— Photographed at end of two weeks. See table VIII.

*Conclusions.*—Seeds, whether in the dry or moist condition, are capable of absorbing hydrocyanic acid gas from the surrounding atmosphere, whether the amount of gas in the atmosphere is large or small per cubic foot. The gas thus absorbed has a marked influence upon the germination of the seeds and upon the subsequent growth of the seedlings. This influence is exerted upon the embryo or upon the enzymes or upon the

stored food material of the endosperm, or it may be that the gas exerts influence directly or indirectly upon two or more of these seed parts. If the grain or seeds are dry the influence of the gas is far less marked than if they are moist, and the drier they are the less the influence of the gas. It would seem that the gas exerts its influence, therefore, through the medium of the moisture contained in the seeds and in the seedlings. Even in older plants it is the more succulent parts that are most readily affected by the gas. The seed coats serve more or less as a protection to the inner seed parts, for as soon as the seedlings escape from the seed coats they are more seriously affected by the gas, and if the charge is sufficiently strong, the seedlings refuse to grow almost as soon as they leave the seed coats. Dry seeds are sufficiently resistant to the influence of hydrocyanic acid gas to be treated for several weeks with an atmosphere saturated with the gas without destroying their vitality. It would be impossible, however, to preserve even dry seeds indefinitely in any strength of the gas, since it eventually penetrates them and impairs and finally destroys their vitality. If the seeds are damp they are much more susceptible to the influence of the gas, and should not remain more than two or three hours in gas of sufficient strength to destroy animal life. If for any reason it becomes necessary for the damp seeds to remain for a longer time in the gas, the injury will be materially lessened by thoroughly washing the seeds in water as soon as they are removed.

The fact that damp seeds are more susceptible to hydrocyanic acid gas than dry seeds would indicate that the gas is taken up more readily by the damp seeds, and the same is true of other gases.

### EFFECT OF HYDROCYANIC ACID GAS ON SEEDS FOR FOOD.

*Dry seeds.*—Only a few experiments have been performed along this line, but probably a sufficient number to determine the point in question, viz., whether dry seeds treated with hydrocyanic acid gas retain enough of the poison to make them

injurious to animal life. Grain was subjected to gas of different strengths and for longer or shorter periods of time, varying from one to sixty days. Grains thus treated were from time to time fed to mice that had been caught without injury and placed in glass cages so that they could be observed constantly. The cages were provided with an abundant supply of air and water and kept at ordinary normal temperature of the laboratory where the mice had been living previous to the beginning of the experiment. Occasionally the mice began eating the grains as soon as they were placed within reach, but as a rule several minutes to several hours elapsed between the time the grains were taken from the hydrocyanic acid gas and the time they were eaten by the mice, thus giving time for any gas that remained in contact with the seed or that had penetrated the seed coat to escape into the atmosphere. In one instance, for example, a mouse was fed one dozen kernels of corn and three dozen grains of wheat that had been for four and one fourth days in an atmosphere containing gas from one gram of potassium cyanid per cubic foot. The mouse began eating the grain at once, and at the end of twenty-four hours had eaten the whole of five grains of corn and had eaten the chit out of five other grains. It had also eaten fourteen grains of wheat and had eaten the chit out of eleven others with no pathological results. Several similar experiments were carried through with like results. Hence it seems safe to conclude that dry grains treated for several days with hydrocyanic acid gas of sufficient strength to destroy insect pests that may be in the grain will in no way affect animal life, and may therefore be used for food without injury.

*Damp seeds.*—The damp seeds were soaked for twenty-four hours and then treated with gas in the same manner as in the preceding experiments, and were kept in the gas for different periods of time varying from several hours to several days. Here as in the germination experiments we find that moisture has a decided influence upon the susceptibility of the grains to the gas. For example: after some corn and wheat had

been soaked for twenty-four hours in water and then left for forty-eight hours in the gas obtained from one gram of potassium cyanid per cubic foot, a mouse in apparently good health was given twelve grains of the corn and thirty-six grains of the wheat. The mouse began eating at once and ate the chit out of one kernel of corn and began on a second kernel when he suddenly became stupid and was unable to walk without staggering. That the mouse was hungry is evidenced by the fact that it began eating as soon as the grain was placed in the cage, and from the fact that it had been given but little food on the preceding day for the purpose of having it hungry enough to begin at once on the grain as soon as it should be removed from the gas. Although the mouse lived for several hours, it eventually died apparently from the effects of the small amount of grain eaten, as it did not eat any more of either kind of grain nor would it eat cheese or any other material placed before it. In general, it was found that if the mice ate the grain immediately after taking it from the gas they became stupid and eventually died from the effects. However, if the grain was allowed to remain for a time out of the gas before it was eaten, no ill effects seemed to be produced, although the grain did not seem to return to its normal condition, as it was never eaten readily even after it became perfectly dry. When the mice could be induced to eat it, as they were in several instances, it did not seem at all injurious. It may be concluded, therefore, that the fumigation of dry grains with hydrocyanic acid gas does not in any way injure the grain for food purpose. And even if the grain is damp it will not be injured for food if it is allowed to air for a short time after fumigating before it is prepared for use.

## SUMMARY.

Dry seeds may be fumigated with the usual strength of hydrocyanic acid gas for the length of time required for the destruction of animal life without in any degree interfering with the germinating power of the seeds.

Dry seeds may be subjected for several months to the

influence of hydrocyanic acid gas at the rate of one gram or less of potassium cyanid per cubic foot without entirely destroying the ability of the seeds to germinate.

Dry seeds subjected to the influence of hydrocyanic acid gas derived from one gram of potassium cyanid per cubic foot will lose their germinating power at the expiration of eight months, while the same seeds subjected to the gas from one third of a gram of potassium cyanid per cubic foot will retain their vitality until the expiration of twelve months.

The exposure of dry seeds for from fifteen to sixty days to the influence of hydrocyanic acid gas from one third to one gram of potassium cyanid per cubic foot will hasten germination and accelerate the growth of the resulting seedlings. Although the acceleration continues for several days, it does not seem to be of sufficient duration and degree to be of any practical value.

Damp seeds are much more sensitive to the influence of hydrocyanic acid gas than dry seeds.

Seeds soaked twenty-four hours or more will not germinate in gas stronger than $0.003^{gm}$ of potassium cyanid per cubic foot, whereas, if the seeds are soaked but twelve hours, they are able to germinate in an atmosphere containing hydrocyanic acid gas from $0.050^{mg}$ of potassium cyanid per cubic foot, and in much less time than when soaked for twenty-four hours.

Seeds soaked thirty-six hours will germinate much more readily than when soaked only twenty-four hours, but will not germinate in a stronger atmosphere of hydrocyanic acid gas than $0.003^{gm}$ of potassium cyanid per cubic foot.

Seeds soaked for twenty-four hours and then left for seven days in an atmosphere of hydrocyanic acid gas will remain inactive while in the gas, and from seven to twelve days after removal, but will eventually germinate to some extent if the strength of gas used does not exceed $0.050^{gm}$ of potassium cyanid per cubic foot, *i. e.*, hydrocyanic acid gas is capable of holding seeds in an inactive state for two weeks or longer without destroying their vitality, even when the conditions are otherwise favorable for germination.

Damp seeds are injured to a much less extent when fumigated with hydrocyanic acid gas if they are washed immediately after removing from the poisonous atmosphere.

The vitality of damp seeds is seriously injured if treated for three hours with gas from $0.25^{gm}$ of potassium cyanid per cubic foot, provided the seeds are not washed after removing from the influence of the gas. On the other hand, damp seeds may be treated with the same strength of gas for six hours with no appreciable injury, provided they are washed and placed in an atmosphere of ordinary air to germinate.

Dry seeds treated for several days with hydrocyanic acid gas of any strength will not be injured for food.

Damp seeds treated with hydrocyanic acid gas of any strength, and even for short periods of time, should not be used for food until several hours after removing from the gas. The effect of the gas eventually passes off and the grain may be eaten with safety, although long exposure to the gas seems to render it unpalatable. Grains and other seeds may be fumigated with hydrocyanic acid gas for the destruction of insect pests without injury to the germinating quality of the seeds and without rendering them injurious as foods.

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# THE TUBER-LIKE ROOTLETS OF CYCAS REVOLUTA.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. XXVI.

A. C. Life.

[WITH TEN FIGURES]

The coral-like outgrowths in connection with the roots of *Cycas revoluta* have long been known. In 1871 and 1872 Reinke[1] published an account of them and described the associated endophytic alga, which he referred to Anabaena (*fig. 10*). In 1894 Schneider[2] published further details, and referred to these structures as root tubercles. My own work was begun at Indiana University and continued at The University of Chicago.

The occurrence of these structures in *Cycas revoluta* is by no means uniform in greenhouse plants, as they are abundant in some cases, few in others, and entirely lacking in still others. They are connected with the upward rising rootlets, usually spreading radiately from the apex and just behind it, and are most abundant at or very near the surface of the ground, but may occur several inches beneath it. They vary considerably in size, but are always larger than the normal roots of the same age, and by branching may form clusters 2.5$^{cm}$ or more in diameter (*fig. 1*).

This branching is apparently dichotomous and such a claim has been made for these rootlets. According to Reinke[3] this fact indicates relationship with the Lycopodiales, while Schneider[2] suggests that it is a case of atavism. If by true dichotomy it is

[1] Einige Bemerkungen über das Spitzenwachstum der Gymnospermen Wurzel. Gött. Nachrichten 530. 1871.

Parasitische Anabaena in Wurzeln der Cycadeen. Gött. Nachrichten 107. 1872.

[2] Mutualistic symbiosis of algae and bacteria with *Cycas revoluta*. Bot. Gaz. 19: 25–32. *pls. 3, 4.* 1894.

[3] Beitrag zur Kenntniss der Gymnospermwurzel. Just's Bot. Jahresb. 1: 205–207. 1873.

meant that the whole of the apical meristem passes into the meristem of the branches, this is not a case of true dichotomy. At an early stage the meristems of the two branches become definitely outlined, but between them, retaining a central apical position, there remains a portion of the original meristem. This true apical meristem gives no indication of continuing the axis, and does not even begin to form bundle elements, but soon becomes indistinguishable, and the later stages of the rootlets show what seems to be a real dichotomy. The conclusion is that this is a case of apparent dichotomy in which the meristem of the main axis ceases to function almost as soon as the meristems of the two branches are differentiated from it. It may be of interest to note that some of the tubercled rootlets do not branch, and that the normal rootlets do not show even an apparent dichotomy.

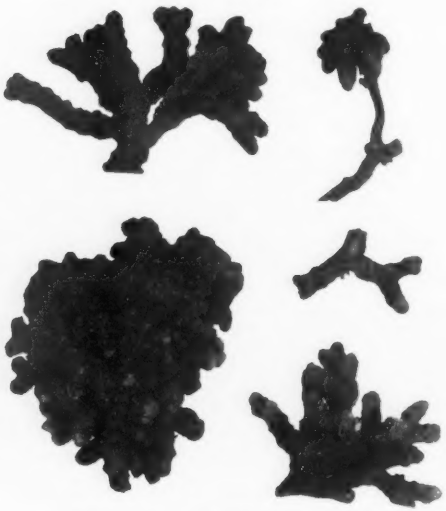


FIG. 1.— Habit of tubercles; nat. size.

A transverse section of one of the tubercles (*fig. 2*) shows a central vascular cylinder like that of the normal root, and a very thick cortex interrupted about midway by the greenish algal zone (*fig. 2, a*). The inner mass of cortex consists of ten or twelve layers of cells. The outer region is more differentiated, consisting of elongated parenchyma cells next to the algal zone, a zone of roundish cells with small intercellular spaces, a layer of cork cambium, and two layers of corky cells.

In longitudinal sections the algal zone is seen to extend from

the base of the tubercle almost to the very apex (*fig. 3*). Where first distinguishable it consists of cells whose contents are somewhat denser than those of the neighboring cells, and before any intercellular spaces appear the cells next to the zone on both sides become very distinctly differentiated into a layer (*f*) resembling a tapetum. When fully developed the algal zone consists of loosely connected cells with large intercellular spaces which are occupied by the algae (*figs. 4, 5*). The radial elongation of these loosely connected cells induced Schneider to call them palisade tissue. Where large lenticels occur there is a break in the algal zone, and instead of the usual layers the round parenchyma cells extend from the phellogen to the vascular cylinder (*fig. 6*). The round cells with their small intercellular spaces form an effective air-conducting tissue.

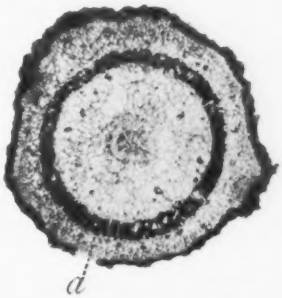



FIG. 2.—Transverse section of a tubercle. × 15. *a*, algal zone.

FIG. 3.—Longitudinal section of tubercle. × 40. *a*, algal zone; *f*, tapetum-like layer, with hyphae.

Lenticels occur in abundance upon the tubercles, and are found near the tip of a root upon which young tubercles are growing. They occur also in thickened primary roots which do not bear tubercles. That they are developed very early in the

growth of a tubercle is evidenced by the fact that they may be seen forming very near the tip. To determine whether these structures are really lenticels, air was forced through the tubercles under water by means of an aspirator. The streams of air which were given off indicated that the structures are lenticels in function as well as in form. It might be inferred, therefore, that the so-called tubercles are used in aeration, but this would seem to be but an incidental result of their structure. It has been shown by Jost[4] that plants deprived of a sufficient supply of oxygen develop air conducting tissue and abnormal growths, and it is possible that this represents the condition of *Cycas*.

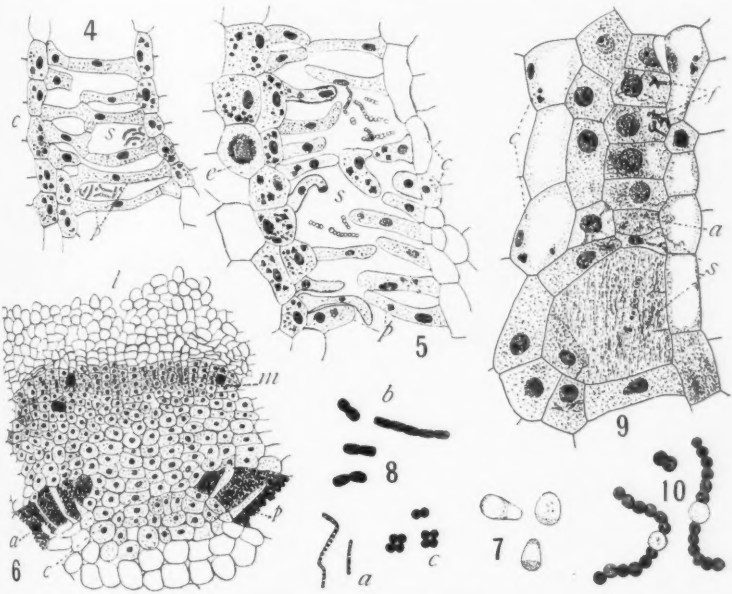
Upon comparing the general structure of the tubercle-like rootlets with those which are normal, it is to be noted that the tubercles have round tips which do not possess a true root cap. Instead of the conical root cap of the normal root they have a sheath of several cell layers extending over the tip and also enveloping the entire tubercle as an outer cortex (*fig. 3*). No such cortex is developed in the normal root.

In studying the fungi and bacteria of the tubercles, cultures were made on agar. From these cultures at least three bacterial forms and an organism resembling the Rhizobium of Schneider[2] were obtained (*figs. 7, 8*). The bacteria included one very large form, a small chain-like form, and a coccus form. The hyphae of fungi were also observed in the cells of the tubercles just in advance of the algal zone (*fig. 9*), but they were not in a condition to be identified. In fact, a zone of differentiated cells extends from the algal zone to the meristem of the tip (*fig. 3*), the cells being shorter than the adjoining cells and their contents more granular.

The fungi and bacteria which are in the cells in advance of the algal zone seem to prepare the way for the algae (*fig. 10*), since their presence seems to result in very much enlarging the small intercellular spaces, which become the relatively large

[4] Ein Beitrag zur Kenntniss der Athmungsorgane der Pflanzen. Bot. Zeit. 45:37–39. 1887.

chambers occupied by the algae. The presence of the fungi and bacteria within the cells seems to retard the nutritive work, so that the cells cannot keep pace with those adjacent. This produces tension which results in a development of spaces, and by




FIGS. 4–10.— *a*, algae of intercellular spaces; *b*, bacteria; *c*, parenchyma; *s*, intercellular spaces of algal zone; *p*, elongated parenchyma; *l*, round corky cells; *m*, cambium of lenticel; *f*, hyphae of fungus; *e*, crystal of calcium oxalate.

FIG. 4. Intercellular spaces of the algal zone. × 120.— FIG. 5. The same. × 190. —FIG. 6. Part of a cross-section, showing a lenticel and a break in the algal zone beneath. × 120.— FIGS. 7 and 8. Bacteria and rhizobia found in cultures from tubercles. × 1425.— FIG. 9. Part of longitudinal section showing beginning of the formation of intercellular spaces of the algal zone, and cells containing hyphae of fungus. × 300.— FIG. 10. Algae found in the tubercle. × 480.

means of this tension some of the cells are broken, while others appear to be broken down by the organisms within them. After the algae have gained entrance, their growth and multiplication probably result in still further increasing the size of these

intercellular spaces, since they become larger the further they occur from the region of origin.

In the early stages of the growth of the tubercles, before they contain the algae, numerous lenticular areas may be observed at their bases and also upon the adjacent part of the root which bears them. These peculiar areas have openings in them which appear as crevices, and as the tubercles grow older the whole area frequently breaks away, and it is doubtless through these rents that the algae effect an entrance. Together with the algae the fungi and bacteria also enter, the latter forms penetrating the cells and causing the enlargement of the intercellular spaces.

In reference to the symbiotic relations which exist between these various organisms it is difficult to speak with any certainty. The fungi and bacteria doubtless find congenial conditions of moisture and food in connection with the algae, and are in turn the principal agents in producing the intercellular spaces in which the algae thrive. It is barely possible that there may be some such chemical attraction between the fungi and algae and the cells of the differentiated layer as has been stated by Miyoshi.[5] It has been demonstrated by Vines,[6] Frank,[7] MacDougal,[8] and others that fungi growing upon the surfaces of cells or within them may aid in nutritive work by converting free nitrogen and the simpler nitrogen compounds into the more complex forms used by the plant. The same function has been attributed to certain algae by Prantl,[9] especially including the nostoc forms. This last observation suggests the possibility of the use

[5] Ueber Chemotropismus der Pilze. Bot. Zeit. **52**: 1–28. *pl. 1*. 1894.

[6] On the relation of the formation of tubercles on the roots of Leguminosae and the presence of nitrogen in the soil. Ann. Bot. **2**: 386–389. 1888.

[7] Ueber die auf Wurzelsymbiose beruhende Ernährung gewisser Bäume durch unterirdische Pilze. Ber. deut. bot. Gesell. **3**: 128–145. *pl. 10*. 1885.

[8] Symbiotic saprophytism. Ann. Bot. **13**: 1–47. *pls. 1, 2*. 1899.

[9] Die Assimilation freien Stickstoffes und der Parasitismus von Nostoc. Hedwigia **28**: 135. 1889.

of the nostoc forms within the tubercles of the cycads in assisting nitrogen assimilation.

In conclusion, therefore, the tubercles of cycads may be said to have at least two functions, that of aerating, and that of assisting in nitrogen assimilation.

THE UNIVERSITY OF CHICAGO.

# BRIEFER ARTICLES.

## WALNUT BACTERIOSIS.

I CHARACTERIZE here briefly a new micro-organism pathogenic to *Juglans regia* and related species, which has been under investigation at this laboratory for several years. Announcements of the isolation of the organism and a demonstration of its pathogenic action on walnuts were contributed several years since to the leading horticultural journals of the Pacific coast. Further communications relative to this disease are in course of preparation, which will enter more fully into the characterization of the organism, its pathogenic powers, its cultural peculiarities, and will give full details as to the nature and treatment of the disease which it causes.

**Pseudomonas juglandis,** n. sp.—A short, rod-shaped micro-organism with rounded ends, actively motile, bearing a single long polar usually wavy flagellum. Length of organism, taken from colony in acid gelatin, set directly from walnut, and stained with gentian violet, 1–2$\mu$, according to whether the germ has just divided or has elongated but not yet divided. Just before separation a pair of germs will usually average about 2$\mu$ in length. Average breadth of organism about 0.5$\mu$. Occurs singly or in pairs, and sometimes in shorter or longer chains. Produces a bright chrome yellow growth on potato and many other media. When growing normally on potato the starch is so acted upon by a diastatic ferment produced by the organism, that it is altered throughout a wide band beyond the margin of the culture of organisms. This band of converted starch may extend 0.5–1$^{cm}$ or more beyond the margin of the growth or germs, appears white to the eye, fails to show normal starch reaction to iodine, yields marked grape sugar reactions, has an exceedingly sharp and well defined limiting outline, often passing so sharply through a cell as to include only the starch grains on one side of the cell. This broad and distinct ferment band distinguishes this organism at once from *Pseudomonas Stewarti* and *P. hyacinthi*, as well as from the more nearly related *P. campestris*, which occasionally forms a weak but much narrower band, and from

all other uniflagellate organisms studied. Organism prefers neutral or acid reaction of culture medium, a moderate degree of alkalinity inhibiting growth; it liquefies neutral and acid gelatin. Produces no gas in fermentation tubes of sugar solutions; growth confined to neck and bulb of tube, hence aerobic, no growth under mica plate. Colonies in malic acid potato gelatin and agar circular; at first clear but soon decidedly yellow, margin sharp. This organism is distinguished from *P. campestris*, the most nearly related species of the genus, aside from the characters already assigned, in producing an abundant and bright yellow pigment on the surface of extracts of the leaves of the following plants, while *P. campestris* produces little or no pigment upon such extracts: walnut (*Juglans regia*), magnolia (*Magnolia macrophylla*), fig (*Ficus Carica*), castor bean (*Ricinus communis*), loquat (*Eriobotrya Japonica*).

Organism strikingly pathogenic to nuts, leaves, and tender branches of *Juglans regia*. In the young walnuts the epicarp and forming shell and kernel are destroyed, in the older nuts the epicarp alone may be affected. The leaves are commonly attacked along the veins and on the petiole, the organism often entering the vessels. The branches become infected near the growing point, and all tissue systems are destroyed, the organism entering and wintering in the pith cavity; it also winters in fallen nuts. An unlimited number of infections may be induced—and thousands have been so induced—by spraying the young nuts with a pure water culture of the organism. This test shows the germ to be one of the most active, self-effective parasitic or pathogenic species of the genus yet known to infect plants.

*Pseudomonas campestris* has not been found infesting the cabbage fields of the regions where the present disease prevails. Walnut bacteriosis is known to exist over large areas in southern California and to a limited extent in the central and northern portions of the state.—NEWTON B. PIERCE, *U. S. Dept. Agric., Div. Veg. Phys. and Path., Pacific Coast Laboratory, Santa Ana, Cal.*

# CURRENT LITERATURE.

## BOOK REVIEWS.

### Vegetable physiology.

THE NEED of a book of moderate compass to present in clear and succinct form the principles of plant physiology is well met by Professor Green's recent volume.[1] In a handy volume of 450 pages the author has discussed the structure and differentiation of the body (35 pp.); the skeleton (17 pp.); the absorption, transport and loss of water (50 pp.); aeration and respiration (29 pp.); the various processes of nutrition, including absorption and synthesis of foods, translocation, storage, digestion, secretion and waste products (156 pp.); energy relations (17 pp.); growth (15 pp.); temperature and the influence of environment on plants (25 pp.); irritability and movement (39 pp.). These are not the author's chapter headings but fairly represent the various topics. He has "endeavored to present the plant as a living organism, endowed with particular properties and powers, realizing certain needs, and meeting definite dangers," and to keep clearly before the reader the fundamental identity of the activities of plants and animals.

In general the presentation leaves little to be desired. Particularly commendable is the treatment of nutrition. The author not only lays stress upon the true nature of foods, from which category he rightly excludes water and carbon dioxid, but discusses clearly photosynthesis, from which he differentiates, none too strongly, the amylogenic function, and presents, as in his earlier work, an excellent chapter on digestion.

The treatment of respiration and the energy relations of plants, however, is not well arranged. To discuss respiration in connection with aeration and before nutrition seems to be a reversal of the logical sequence and that to no gain. It needs to be brought into intimate relation with nutrition, of which it is a phase, and also with the release of energy, of which it is one method. Aeration, though incidental to respiration, should be treated in connection with gas absorption, just as root hairs are discussed in connection with water absorption.

The handling of osmosis might be much improved by a broader physical treatment, for there is no process whose fundamental principles are so little comprehended by most students. The author seems to overestimate the importance of root pressure in the transport of water through the stems, for

[1] GREEN, J. REYNOLDS: An introduction to plant physiology. 8vo. pp. xx + 459. *figs. 184.* London: J. and A. Churchill. 1900. 10s. 6d.

it certainly has no effect beyond the cortex of the root when transpiration is active. On the other hand, the presentation of the probable relation of evaporation and osmosis in the mesophyll to water transfer is very satisfactory.

The illustrations are remarkably unequal. Some are excellent; some are crude, but sufficient; some are so diagrammatic, without such remark, as to be misleading; and some disfigure a book which deserves the best possible engravings. We suspect some of the worst of being relics of a long-deceased "botany," resurrected from the publishers' stock-room. Many of the illustrations, though not original, are not credited to their sources, while others are; of this no explanation is given.

No references are made to original papers or to other works; only in a few cases is the proponent of any particular view or theory referred to; and controverted points are scarcely alluded to. The danger from this is that the student may get the too common impression that the book deals out finally settled knowledge. It is difficult to know where to draw the line between the necessary dogmatism of the elementary work and the discussion of the treatise, but we believe in showing up the gaps in a subject fully. While this book only professes to be "an introduction," it is nevertheless so thorough that it would have been improved by a *selected* bibliography following each of the various topics. For though we have Pfeffer's treatise at hand, its citations of literature are too detailed for the student of elementary physiology, and he would have profited greatly by the same judicious sifting of the literature as Professor Green has made of the facts.—C. R. B.

### The problems of life.

THE FUNDAMENTAL problem of physiology is the constitution of living matter. But we are so far from a knowledge of the chemistry of proteids, not to mention protoplasm, that the best we can do now is to attempt the framing of logical and consistent hypotheses, in the hope that these will suggest research in fruitful lines. If the true character of such hypotheses is kept clearly in view, they may prove helpful, but there is always a danger that the hypothesis may be held so tenaciously that new facts are distorted to fit our interpretation of other facts.

There is before us the first part of a work by Dr. Giglio-Tos, of the University of Turin, which is an attempt to set forth a logical and consistent hypothesis of the organization of protoplasm and its fundamental functions, notably assimilation, reproduction, respiration, photosynthesis, and cell division.[2] A second part is to discuss ontogeny and its problems.

[2] GIGLIO-TOS, ERMANNO: Les problèmes de la vie: Essai d'une interpretation scientifique des phénomènes vitaux. 1e partie: La substance vivant et la cytodiérèse. 8vo. pp. viii + 286. *figs.* 33. Turin: The author, Palazzo Carignano. 1900. 10 francs.

The general thesis of the book is that vital phenomena are explicable without invoking hypothetical or mysterious forces and are all referable to relatively simple fundamental causes. Since the minutest observable organisms undergo fission, the author makes the assumption that fission occurs also in the molecules of living substance. This he illustrates by the behavior of certain chemical compounds. Methyl-ethyl-ketone, for example, on taking up three atoms of oxygen, cleaves into two molecules of acetic acid. The chemical analogy may be carried further. By treating the acetic acid molecules with phosphorus pentachlorid, and the acetyl chlorid so formed with zinc ethyl, there are finally produced four molecules of methyl-ethyl-ketone and in the course of the process several by-products. Certainly such an analogy, if it be nothing more, renders easily conceivable the author's hypothesis that assimilation of atoms or atomic groups from the medium brings about an increase and a rearrangement of the atoms in each molecule of living substance. When the proper relations within the molecule are reached, it divides into two new ones like the original; or into two (alike) which through a subsequent cycle of development produce molecules like the original; or into two (unlike), only one of which develops and reproduces the original molecule, while the other finally produces again unlike molecules. By assuming this different behavior the author explains the production of nonliving matter by living, and the origin of genetic and somatic plasma.

The respiratory and photosynthetic activities of these living molecules are elucidated in terms of this hypothesis; certainly what we know of them falls in with it easily.

The next assumption is that many unlike biomolecules, to use the author's word for living molecules, are aggregated into living particles, or biomores, in which they have an arrangement determined by the chemical affinity of the various atoms and groups, and shifting as the chemical constitution changes. The life of the biomore, however, does not depend on its constitution but on the life of the biomolecules.

The aggregate of biomores, submerged in water (not of constitution as Nägeli held, but of capillarity), constitutes the bioplasm. Any view as to the morphological structure of the bioplasm, whether the filar structure of Flemming, the reticular of Frommann, the alveolar of Bütschli, or the granular of Maggi and Altmann, is equally consonant with this theory.

The bioplasm is not of indefinite extension but consists of small masses, each a symbiotic system of unlike biomores, constituting a biomonad. A very complex biomonad, especially when biomores constituting a nucleus are present, is a cell.

Cell division is based upon the same fundamental principle as the fission of the biomolecules. In them it is not mere addition of atoms which suffices to bring about division, but their mutual relations and orientation. In the

biomores division again depends on the nature, number, *and arrangement* of the biomolecules. In the biomonad, division is possible (1) because the biomores are mobile, being in liquid; (2) because they exercise a mutual attraction (shown by their union into masses giving parts of the cell their definite characters), and consequently assume a determinate arrangement. But division of the cell is completely independent of its structure, though the figures accompanying division, such as the spindle, the equatorial plate, etc., are dependent upon structure. The efficient cause of division is indeed always the same, whether in biomolecule or cell, namely, the mutual orientation of the parts; whatever the number, nature, or structure may be, division is inevitable when the proper arrangement is attained. Assimilation is indispensable to division, but not always sufficient. The discussion of cell division is elaborate and is illustrated by diagrams which make the presentation very clear and the process fascinatingly simple — would that it were so.

Such is a very brief outline of the hypothesis. Of course, it adds nothing to our knowledge, and it would be easy to revile it as an unstable pile of assumptions. But the real questions are, Does it take account of the present facts and coordinate them? Will it suggest fruitful research? That it takes account of all the facts is improbable; that it does fairly coordinate the more important ones (alas, too few) seems evident. That it will stimulate investigation remains to be seen. At any rate it deserves attention for what it purports to be, namely, an attempt to give a scientific interpretation of vital phenomena.— C. R. B.

## MINOR NOTICES.

ONE OF THE latest of the series of Temple Primers is a little volume on *Plant life and structure* translated from the German of Dr. E. Dennert by Clara L. Skeat.[3] The author seems to recognize no organisms as plants but the seed plants, and continually makes assertions of the most comprehensive sort which are true only of green plants. Indeed he is rather given to generalizations, both regarding structure and function, and to teleology of the Paley type. In many minor matters and in some important ones the book is not up to the times; Goethean metamorphosis, sexual terms for the sporophyll and microspores, and much faulty physiology might have been more easily forgiven in a book dated a decade or two ago. But the best to be said of this booklet is that it is better than many more pretentious works and good enough for one to regret that it is not better.— C. R. B.

AMONG the plastic products of plants one of the groups most interesting chemically and most valuable commercially is the volatile oils. In their manufacture many firms have been engaged, but none so extensively, so

[3] DENNERT, E.: Plant life and structure. Translated from the German by Clara L. Skeat. 16 mo. pp. viii + 115, *figs. 56*. London: J. M. Dent & Co. (undated). New York: The Macmillan Company. 40 cents.

exclusively, or more scientifically than Schimmel & Co., of Leipzig. Not content with much original work in the chemistry of these substances and costly experimentation with methods of manufacture, this firm commissioned Dr. E. Gildermeister, of Leipzig, and Dr. Fr. Hoffmann, of Berlin (the latter long and honored leader in pharmaceutical affairs in this country), to prepare a work on volatile oils,[4] treating them in an exhaustive and critical manner from the modern standpoint. This work, published about a year ago, has been translated into English by Dr. Edward Kremers, of the University of Wisconsin. The recent rapid development of the knowledge of the volatile oils makes the present volume doubly useful. With the chemistry of these bodies it happily combines much interesting historical matter and a description of the modern processes of distillation. Abundant references to original chemical sources make the work an important aid to the investigator.

Though primarly chemical and technical, the list of plants, arranged according to families, from which volatile oils are obtained will be interesting for the botanist and the whole book is a mine of information. Four hundred and thirty oils are described, the botanical sources, percentage present in various parts, mode of preparation and composition being given.—C. R. B.

## NOTES FOR STUDENTS.

HAROLD L. LYON, of the University of Minnesota, has announced[5] that Nelumbo, "both in its anatomy and embryogeny conforms to the type of the monocotyledons." His full paper will be awaited with interest.—J. M. C.

LEWIN[6] contradicts the view of Stahl that raphides are important as a means of protection against herbivorous animals. There is no evidence of mechanical injury to animals, nor of poisonous effects being produced through eating plants that contain these crystals.—H. C. COWLES.

MIYOSHI[7] has performed a number of experiments in order to determine the influence of various substances in the soil or water upon flower colors. His results are not uniform, though he finds in general that aluminium compounds change lilac to blue (as Molisch previously observed), while potash changes lilac to green, and many acids change it to red.—H. C. COWLES.

W. C. WORSDELL[8] has concluded that the Bennettitales are more primitive than the modern cycads, as shown by their stem structure, radial

[4] GILDERMEISTER, E. and HOFFMANN, FR.: The volatile oils. Written under the auspices of the firm of Schimmel & Co., Leipzig. Authorized translation by EDWARD KREMERS. 8vo. pp. viii + 733, *figs. 83, maps 4*. Milwaukee: Pharmaceutical Review Pub. Co. 1900.

[5] Science **13**: 470. 1901.

[6] Ber. deut. bot. Gesell. **18**: 53–72. 1900.

[7] Bot. Centralbl. **83**: 345. 1900.

[8] The affinities of the mesozoic fossil *Bennettites Gibsonianus*. Ann. Bot. **14**: 717–721. 1900.

sporophyll, and terminal ovule. In reference to the radial character of the primitive sporophyll the author accepts Celakovsky's view, and also regards the peculiar ovuliferous stalks as foliar rather than axial structures.—J. M. C.

D. H. SCOTT[9] has described a new genus of lycopods, *Lepidocarpon* by name, which shows features indicated by the title of the paper. It is from the Lower Coal Measures and also from a much lower horizon, the Calciferous sandstone series, and the strobili resemble those of Lepidostrobus. The megasporangia, however, mature and retain a single large megaspore, and each sporangium becomes covered by a definite tegument which is an outgrowth from the sporophyll, and completely encloses it except for a slit-like opening above. So much of the sporophyll persists as is necessary to complete this testa-like covering, and the whole seed-like structure falls off with its retained and germinated megaspore.—J. M. C.

DR. E. O. JORDAN[10] has published recently a paper upon the bacterial self-purification of streams, the observations having been made during a study of the chemical and bacterial condition of the Illinois river and its tributaries, undertaken in behalf of the sanitary district of Chicago. The phase of self-purification considered is that which relates to the disappearance of the sewage bacteria. Although the conclusions are not to be regarded as final, a lessening of the bacterial content seems to admit of no question. In fact, the observations show that the Illinois river at Ottawa had become nearly free from the great mass of sewage bacteria with which it was originally laden. The probable factors in this result seem to have been dilution, sedimentation (leading to exhaustion of food supply), or action of sunlight. The influences of mechanical agitation and aeration, and of plankton, do not seem to be factors which enter into the problem in connection with the Illinois river. —J. M. C.

JOHN WEINZIRL[11] has recently published a paper upon "The bacterial flora of the semi-desert region of New Mexico with especial reference to the bacteria of the air," in which he records the result of a two-year study. Both quantitative and qualitative examinations were made. The quantitative data were obtained by the filter method, sand being used for the filtering substance. Five determinations made in the vicinity of the University of New Mexico gave an average of aboat forty-two bacteria per cubic meter of air. Eleven determinations in the residence district of Albuquerque yielded

[9] On the occurrence of a seed-like fructification in certain paleozoic lycopods. Ann. Bot. **14**: 713–717. 1900.

[10] Some observations upon the bacterial self-purification of streams. Jour. Exper. Medicine **5**: 271–314. *pl. 20.* 1900.

[11] Jour. Cin. Soc. Nat. Hist. **19**: 211–242. 1900.

an average of one hundred and forty-three per cubic meter. Comparison is made with the Mont-Souris results, but no mention is made of Tucker's observations in Boston. Ten organisms, presumably distinct, are described with some detail. It is not stated whether the "recommended procedures" have been employed. The organisms described are characterized as a whole by their inability to ferment sugar and to peptonize gelatin.—E. O. JORDAN.

MISS ETHEL SARGANT[12] has published an exceedingly interesting paper upon double fertilization, bringing together the contributions to date and discussing the questions that have been raised. The bibliography of the subject is represented now by at least eighteen titles, and the phenomenon has been recorded for about twenty-five species. The author inclines to the view that the triple fusion is a true act of fertilization between a male cell and an egg, interfered with and rendered abortive by the introduction of the non-sexual antipodal nucleus. The result is not a normal embryo, but a small and short-lived mass of tissue. Boveri's experiments with the eggs of sea urchins, in which more than one sperm was forced to unite with egg nucleus, are cited to prove this probable result of more than double fusion. The theory is advanced that the third nucleus is introduced to secure the degeneracy of the resulting tissue. If this is true, the definitive nucleus has descended from one which was the result of true fertilization, and the participation of the third nucleus is an added feature.—J. M. C.

ITEMS OF TAXONOMIC INTEREST are as follows: EDWARD L. GREENE (Pittonia **4**: 242–284. 1901), in continuing his "Studies in the Compositae," has made a special attack upon *Bidens*. After an interesting account of the history of the genus, of *B. frondosa* L., and of *B. cernua* L., he describes twenty new species, thirteen of them being American analogues of *B. cernua*, and seven of them segregates of *B. chrysanthemoides* Mx. *B. Beckii* is given generic rank, and is associated with two new species under the name *Megalodonta*. In the same fascicle new species are described under Conoclinium (3), Eupatorium (8), and Antennaria.—C. S. SARGENT (Rhodora **3**: 19–31. 1901) has described thirteen new species of *Crataegus* from the Champlain valley, remarking that this is one of the richest regions in the world for forms of Crataegus.—P. A. RYDBERG (Bull. Torr. Bot. Club **28**: 20–38. 1901), in the fourth paper of his series entitled "Studies on the Rocky mountain flora," describes new species under Arnica (2), Artemisia, Picradenia, Antennaria, Aster, Townsendia, Erigeron (3), Valeriana, Campanula, Castilleia (3), Mimulus, Pedicularis, Pentstemon (3), Polemonium, Gilia, Phacelia, Lappula, Cryptanthe, Mertensia (4), Mentzelia, Impatiens, Geranium, Lupinus (2), Astragalus, Aragallus, Trifolium, and Lathyrus.—C. V. PIPER (*ibid.* 39–45, in the fifth paper of his series entitled "New and noteworthy northwestern

[12] Recent work on the results of fertilization in angiosperms. Ann. Bot. **14**: 689–712. 1900.

plants," describes new species under Arabis, Trifolium, Astragalus, Solidago, Erigeron, Antennaria, Artemisia, Crepis, Dodecatheon, Gilia, Phacelia, Lappula, and Mimulus.—L. M. UNDERWOOD (*ibid.* 46–47) has described a new Adiantum from New Mexico.—J. M. C.

BROWN and ESCOMBE have under way one of the most important physical researches of recent years. They have set forth some of their results and have applied them to plant functions in a paper on the "Static diffusion of gases and liquids in relation to the assimilation of carbon and translocation in plants."[13] Blackman's interesting results (1895) concerning the diffusion of $CO_2$ through stomata are fully substantiated. The authors further find that with small openings *a*) the rate of diffusion varies as the diameter of the orifice; *b*) multiperforate septa do not hinder diffusion when the openings are about ten diameters apart; *c*) decrease in per cent. of area of holes is not followed by proportional decrease in amount of diffusion; *d*) the laws hold for both gases and solutes. Assuming an analogy with lines of force about an electrified disk, they find these results accord with mathematical calculations. Applying these principles to plants the authors conclude that 1) in an ordinary leaf (*Helianthus annuus*) the stomata are sufficient to permit the diffusion of five or six times as much as $CO_2$ as is actually used by the plant; 2) resistance to the absorption of a greater quantity of $CO_2$ lies in the relatively slow diffusion of the $CO_2$ after solution; 3) the stomata are more than sufficient to permit the escape of the observed amounts of water vapor by diffusion without any mass movements; 4) continuity of protoplasm may have more to do with translocation of foods than has been supposed hitherto, since over 60 per cent. of diffusion possible through an orifice the full size of the pit would take place through the many minute perforations, although their area be only 0.84 per cent. of the total membrane of the pit.—T. C. FRYE.

IN A RECENT PAPER by A. H. R. Buller[14] on chemotaxis in fern sperms it is shown that these cells are attracted not only by malic and maleic acids and several of their salts (as was known before), but also by numerous salts of the inorganic acids. Potassium and sodium tartrate and potassium oxalate also attract. Sperms of *Gymnogramme Martensii* were used and were tested by Pfeffer's method of capillary tubes. The concentration necessary for attraction is usually $\frac{1}{100}$ to $\frac{1}{10}$ normal. With malic acid it is $\frac{n}{10000}$ to $\frac{n}{1000}$, and with sodium malate $\frac{n}{1000}$ to $\frac{n}{10}$. Nitrates and chlorids of sodium, ammonium, and calcium do not attract, nor does lithium nitrate. The choice of compounds to be tested was made, apparently, with the aim of making a catalogue of attracting substances rather than of determining the real nature

[13] Phil. Trans. Roy. Soc., London, B. **193**: 223–292. 1900.

[14] Contributions to our knowledge of the physiology of the spermatozoa of ferns. Ann. Bot. **14**: 543. 1900.

of the attraction. The results are tabulated according to De Vries' obsolete isotonic coefficients, and in order to be studied need to be rearranged by base and acid. The small number of salts of any given acid makes it utterly impossible to draw any conclusion as to the nature of the attraction. The author's propositions in this regard may or may not be substantiated later; several hypotheses might be formulated which would explain equally well the cases cited. It is unfortunate that this paper (following that of Garrey[15] by nearly a year) should carry our knowledge of this important subject of chemotaxis such a little way further than it was carried by that writer. We have tried, with some success, to coordinate the results given in these two papers, but nothing definite can be attained, so far as fern sperms are concerned, until we have more data. Chemical principles must be brought into requisition in the selection of salts to be tested as well as in the interpretation of results. The author makes an interesting observation with regard to starch grains in the vesicle of these sperms. During the swarm period the grains diminish in size and often disappear entirely. The conclusion is drawn that the starch is made use of by the active sperm, being probably oxidized for the production of kinetic energy. Unhappily, no observations on the hydrolysis of these grains were made. We may suppose them to be converted into glucose by an enzyme formed in the vesicle. Thus we might have the non-nucleated cytoplasm of the sperm mother cell doing nutritive work for the moving sperm. This, if shown to be the case, might throw some light on the phenomena occurring in the male cells of the lower gymnosperms.— BURTON EDWARD LIVINGSTON.

AMONG RECENT CONTRIBUTIONS to paleobotany the following papers may be mentioned: LESTER F. WARD (20th Ann. Rep., U. S. Geol. Survey, 1900), with the collaboration of Fontaine, Wanner, and Knowlton, has published an extended account of the Triassic and Jurassic floras of the United States. The various areas are systematically treated, and much new material is incorporated. A large number of plates accompany the work, many of which illustrate Ward's recently described genus Cycadella. A similar report on the Cretaceous is to be expected soon from the same source, and will be heartily welcomed, inasmuch as the literature is considerably scattered. Ward has also published a very interesting popular report on the petrified forests of Arizona, which has been issued by the United States Geological Survey.— F. H. KNOWLTON has published on the flora of the Montana formation (Bull. 163, U. S. Geol. Survey, 1900); this together with his previous papers on fossil plants from Idaho and Yellowstone Park adds greatly to our knowledge of the late Cretaceous and early Tertiary floras of that part of the United States. — DAVID WHITE (20th Ann. Rep., U. S. Geol. Survey, 1900) has worked out

[15] The effects of ions upon the aggregation of the flagellated infusoria. Am. Jour. Phys. 3: 291. 1900.

in great detail the stratigraphic succession of the fossil floras of the Pottsville formation in the Carboniferous of Pennsylvania.—A. C. SEWARD, whose study of the fossil history of Gingko has been briefly noted in this journal (30: 139), has published on the Wealden flora of Bernissart (Mem. Mus. Roy. Hist. Nat. Belg., 1900); the ferns dominate in these beds rather than cycads, but there are no angiosperms, although the Wealden is commonly regarded as equivalent to the Potomac beds of our country.—GRAND 'EURY has given some very interesting accounts (Compt. Rend. 130: 871, 988, 1167, 1366. 1900) of the Carboniferous forests of France. By his study of the plants preserved *in situ*, he concludes that most of the Calamites and some of the tree ferns grew in the water; the herbaceous ferns probably grew largely on hummocks. Even Cordaites seems to have grown in swamps, and Grand 'Eury suggests analogies with Taxodium and the Dismal swamp of today. The prevailing horizontality of the roots strikingly suggests swamp habitats. The author doubts if we have evidence of upland vegetation.—At the last meeting of the British Association (Geol. Mag., Jan. 1901) Seward, Kidston, and others discussed Carboniferous conditions, as indicated by plant fossils. Little new material was added, though Seward suggests that the xerophytic structures of Carboniferous plants may perhaps be accounted for by swamp habitats.—PENHALLOW (Brit. Assoc. Adv. Sci., 1900) has made an interesting report on the flora of the Canadian Pleistocene. Interest was aroused a few years since by Coleman's discovery of the papaw and osage orange in interglacial beds near Toronto, indicating a genial climate between ice-sheets. Over eighty Pleistocene species are now known from Canada. As Knowlton suggests in discussing this report in *Plant World* for January, there is a wide field for work in the study of Pleistocene floras in America. The poverty of our information in this respect is in striking contrast with the wealth of knowledge as to the Pleistocene of Europe.—H. C. COWLES.

THE FORMATION OF TETRADS has lately been investigated by H. O. Juel.[16] The contribution consists of three distinct papers which may be considered separately.

I. *Tetrad formation in the ovule of Larix.*—The general relationships between the reproductive organs of pteridophytes and spermatophytes have long been known, but while it is accepted that the pollen grain arises by a tetrad division, just as the spores of pteridophytes, it is generally believed that the megaspore of spermatophytes is formed without such a division. Dr. Juel studied the ovule of *Larix Sibirica* from an early stage in the development of the mother cell of the megaspore to the beginning of endosperm formation. The paper is of special interest as the first to treat this portion of the life history of a gymnosperm from the standpoint of modern

[16] Beiträge zur Kenntniss der Tetradenbildung. Jahrb. f. wiss. Bot. 35: 626–659, *pls. 15, 16.* 1900.

cytology. In material collected about the middle of April, before the snow had disappeared, the mother cell of the megaspore is easily distinguished by its large size, and by the abundance of starch. The first division is heterotypic, and shows the reduced number (12) of chromosomes. At the poles of the spindle are granular masses which may possibly represent centrosomes, although the author is not willing to commit himself to this interpretation. During the anaphase the starch disappears, a cell wall is formed, and each of the two daughter nuclei divides, this time by a homotypic division, giving rise to a row of four megaspores, the lowest of which germinates and produces the gametophyte. By comparing this series with the development of the microspores, which has been thoroughly studied in Larix, the author reaches the conclusion that the two series are homologous, and that the megaspore, like the microspore, arises by a tetrad division. While the conclusion is not new, the evidence supporting it is valuable.

II. *The tetrad formation in a hybrid plant.*—It has long been known that hybrids are inclined to be sterile, and that the pollen of hybrid plants is commonly imperfect. The present paper deals with the formation of the tetrad in *Syringa Rothamagensis*, a hybrid between *S. vulgaris* and *S. Persica*. The form did not prove to be favorable for such a problem, because the pollen of both parents is poor, in *S. vulgaris* about 50 per cent. of the pollen grains appearing to be incapable of functioning, and in *S. Persica* normal pollen being quite rare. The latter form is almost as sterile as the hybrid. In all three forms the development is normal up to the formation of the pollen mother cells. In the hybrid it was found that while most of the divisions in these cells were mitotic, there were also numerous instances of amitotic division, and abnormalities in the chromatin and in the achromatic figure were frequent.

III. *The development of the pollen grain of Carex.*—As a rule, the pollen mother cell of a spermatophyte gives rise to four pollen grains, but it has been reported that in the Asclepiadaceae and Cyperaceae the mother cell gives rise to one pollen grain only. A careful examination of *Carex acuta* showed that the wall of the pollen mother cell becomes the wall of the pollen grain. It also showed that the tetrad divisions take place, but the walls are imperfect and only one cell of the tetrad develops into a pollen grain, the other three being crowded out, just as in the megaspore series three potential megaspores are crowded out by the one that functions.—CHARLES J. CHAMBERLAIN.

# OPEN LETTERS.

## THE ROCHESTER CODE.

In the course of his article on nomenclatorial principles, published in the March issue of the BOTANICAL GAZETTE, Mr. M. L. Fernald discusses at some length Professor Underwood's recent treatment of the fern genera in this country, making the following statement in that connection:

> In Britton and Brown's *Illustrated Flora*, published in 1896, fifty-nine species of true ferns are recognized, and the names, we are told, are those authorized by the Rochester code. But in Professor Underwood's latest treatment more than *25 per cent.* of those very species appear under different names — still the names authorized by the Rochester code.

Mr. Fernald then presents, in support of this statement, a comparative table of fifteen northeastern ferns, with the names used in Britton and Brown's *Flora* and those in the last edition of Underwood's *Our Native Ferns* given in parallel columns. This table, as an illustration of the remark above quoted, cannot fail to be misleading, since Mr. Fernald evidently wishes the reader to draw the conclusion that the Rochester code is an uncertain guide, and that the same author may interpret it in different ways. In order to ascertain how far such a deduction is to be considered reliable, let us analyze briefly the supposed divergences between Professor Underwood's interpretation of the code in 1896 and in 1900, the dates of the two works mentioned. I follow substantially the same order as that of the table.

1. *Onoclea Struthiopteris*, being regarded by Professor Underwood now as generically distinct from *O. sensibilis*, is separated under the first available generic name, *Matteuccia* since *Struthiopteris* had been earlier applied to *Lomaria*.

2. *Filix* replaces *Cystopteris*, and *Phyllitis* supplants *Scolopendrium* because the first mentioned names have been proven to be the older. This is in strict conformity to the requirements of the code, notwithstanding the fact that conservative botanists would not admit the change.

3. The type of *Dicksonia* being a tropical tree fern, the American herbaceous plant is very properly separated as a genus under the first available name. The various species of *Polystichum* are also segregated from *Dryopteris*, and the latter name is not abandoned, as might be inferred from Mr. Fernald's table. It certainly involves no novel or unusual interpretation of the Rochester code to divide an original aggregate into what later study may prove to be distinct elements; and in the light of numerous new species of

Antennaria of the *plantaginifolia* group that have been proposed from time to time by Mr. Fernald, it is pertinent to inquire whether he does not himself recognize the necessity for occasional segregations. Botanists of the last century, who were familiar with *A. plantaginifolia*, as they supposed, would probably be fully as dismayed over the expansion of this species as modern fern students are likely to be over the division of Dryopteris.

4. *Phegopteris Robertiana* and *Notholaena dealbata* are examples merely of the elevation of varieties to specific rank, an everyday practice among botanists of all shades of opinion.

5. The case of *Pellaea* is analogous to that of Dryopteris.

6. *Cheilanthes gracilis* being a homonym, the first available name, *C. Feei*, is taken up for the species.

Applying the process of exclusion to Mr. Fernald's table in the light of the above remarks, it will be observed that of the fifteen species which he cites, the names of only two are the result of an altered interpretation of the code. These are *Pteridium* for *Pteris aquilina* and its allies, and the restoration of *Asplenium thelypteroides* for *A. acrostichoides*. If we assume the same ratio to hold good throughout Professor Underwood's work, we shall find that all but about 4 per cent. of the changes are the legitimate outgrowth of added research, consisting of corrections of homonyms, division of aggregate genera and species, etc.; and the same changes would probably have been made by the same author under almost any system of nomenclature. On the other hand it may be considered excellent testimony to the soundness of the Rochester principles that after the application to them of Professor Underwood's method of determining generic types so small a percentage of actual changes should occur. The citation of such cases as those discussed above affords no basis whatever for adverse criticism of the code, since, as already explained, the same course might be pursued even by opponents of the Rochester nomenclature.—CHARLES LOUIS POLLARD, *U. S. National Museum*.

# NEWS.

THE *Asa Gray Bulletin* has been merged into the *Plant World*. Mr. Cornelius A. Shear becomes one of the editorial staff.

PROFESSOR J. REYNOLDS GREEN'S work on Enzymes has been translated into German by Dr. Wilhelm Windisch, and published by Paul Parey, Berlin.

MR. SAMUEL M. COULTER, fellow in botany at The University of Chicago, has been appointed to an instructorship in the Shaw School of Botany of Washington University.

PROFESSOR DR. EDUARD STRASBURGER has been elected a member of the French Academy of Sciences, and the order of "Rote Adler, III Classe, mit der Schleife" has recently been conferred upon him.

MR. FRANK S. COLLINS, the phycologist, of Malden, Mass., has recently been elected a resident fellow of the American Academy of Arts and Sciences (Boston), and Mr. Cyrus G. Pringle, the veteran collector, of Charlotte, Vermont, has been elected an associate fellow.

THE ALSTEAD School of Natural History is held at Alstead Center, N. H., for five weeks of the summer. In 1901 it offers instruction in general botany by Mr. M. L. Fernald of the Gray Herbarium; and in mycology (fleshy fungi) by Mr. Hollis Webster, of Boston.

MR. L. C. CORBETT, horticulturist of the Agricultural College at Morgantown, West Virginia, has accepted a position in the Bureau of Plant Industry in the United States Department of Agriculture. His work will include investigations in regard to floriculture and gardening.

THE assistant professorship of botany in the University of Tennessee has been made a full professorship, and the present incumbent, Mr. S. M. Bain, has been promoted thereto. The department of botany is said to be thoroughly equipped and to be making satisfactory progress in every way.

A HANDSOME silver loving-cup was presented by a number of teachers to Mr. Thomas Meehan, the veteran horticulturist and botanist of Philadelphia, on the occasion of his seventy-fifth birthday. Mr. Meehan has been a member of one of the sectional school boards in Philadelphia for twenty-three years.

MR. JARED G. SMITH, formerly in charge of the Section of Seed and Plant Introduction in the United States Department of Agriculture, has been selected to organize the territorial Experiment Station in the Hawaiian islands. Mr. Ernst A. Bessey succeeds him as "Assistant in Charge," the Section having been placed under the Bureau of Plant Industry.

THE Botanical Department of Wellesley College has received a gift of $25,000 from Mr. H. H. Hunnewell of Wellesley, who has already manifested his interest in the college by opening his pinetum and orchid conservatories to botanical classes. The money will be used as an endowment for the department, and the income will be used to meet the yearly needs.

MR. A. S. HITCHCOCK, professor of botany at the Kansas Agricultural College, Manhattan, Kansas, has been appointed assistant agrostologist in the United States Department of Agriculture. Mr. H. F. Roberts, instructor in the Shaw School of Botany, and formerly a graduate student at The University of Chicago, has been appointed Professor Hitchcock's successor.

THE DEPARTMENT of botany of Marine Biological Laboratory has issued its announcement for the season of 1901 (to be obtained from Dr. Bradley M. Davis, University of Chicago). A course in cryptogamic botany is offered by Drs. Davis and Moore; phanerogamic botany by Dr. Shaw; plant physiology by Dr. True; and plant cytology by Dr. Davis and Mr. Lawson. An attractive course of open lectures will also be given.

IT IS proposed to establish a quarterly journal of biological statistics under the name *Biometrika*, which may serve as a means not only of collecting under one title biological data of a kind not systematically collected or published in any other periodical, but also of spreading a knowledge of such statistical theory as may be requisite for their scientific treatment. The movement is in charge of Professor Karl Pearson, of University College, London, to whom tenders of support should be sent.

THE Act of Congress, making appropriations for the United States Department of Agriculture for the year beginning July 1, 1901, contains several important items pertaining to investigations in botanical lines conducted by several divisions in that department. The Divisions of Vegetable Physiology and Pathology, Botany, Pomology, Agrostology, and Gardens and Grounds are grouped into a bureau to be known as the Bureau of Plant Industry. The divisions will retain their individual organizations as heretofore and will continue to work along lines similar to those which they have already developed. The total appropriation for the Bureau of Plant Industry is $204,680. The Division of Forestry is also made a bureau for which there is appropriated $185,440.